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## Editorial Board

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# Determination of Morphological Characteristics of the Wetland Sediments Inekli, Azapli and Golbasi Lakes in the Eastern Mediterranean Region

**Ahu Alev ABACI BAYAN[1*], Kadir YILMAZ[2]**

[1]The University of Ahi Evran, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Kirsehir/Turkey
[2]The University ofKahramanmaras Sutcu Imam, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Kahramanmaras/Turkey

*Corresponding Author: ahu.abaci@ahievran.edu.tr

## Abstract

In this study, the most important wetlands in the Golbasi Depression in the Eastern Anatolian Fault Zone, morphological features of the Golbasi Lakes (Inekli, Azapli and Golbasi Lakes) have been examined. The lake, the water is sweet, but not suitable for drinking, because of included in the karstik tectonic lakes group in terms of formation. The extension of the lake, is east-west direction, it is seen that there is plateau area after the plain area is found to the south. This area, to determine for morphological characteristics, soil profiles were opened at 13 different locations. Inekli-1, Inekli-7, Azapli-1, Azapli-4 and Golbasi-1 profiles, on the ground formed on the main materials formed around the Golbasi Lakes, and Inekli-2, Inekli-3, Inekli-4, Inekli-5, Inekli-6, Azapli-2, Azapli-3 opened on materials that were transported to the lake area were profiles between Azapli and Golbasi Lakes. The soil colors of 43 soil horizons in each professor were determined dry and wet by using Munsell color scale, soil structures were investigated and the hardness, tackiness and plasticity properties of the soil were determined by the findings of this study.

**Keywords:** Golbasi Depression, wetland, soil, morphological property

## INTRODUCTION

In this study, wetlands are described as the natural systems which provide service to both local people and country with constituting the most fertile and the most substantial ecosystems of the earth. According to Ramsar Convention on Wetlands, wetlands are defined as ‘areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters’ (Ministry of Environment, 2000). Wetlands which have such an importance have been forced to undergo various changes over time, either naturally or through human interference (Abacı Bayan, 2016). The fertility potential of lands of lake or wetlands which dried up for any reason and transform into terrestrial environment has affected the factors such as structure formation, plasticity and capacity of seed germination. It has been stated that aftermath of drying process of wetlands, whereas structure has not developed; in arid lands dried consistency is solid and rigid, moist consistency is stiff and very stiff, wet consistency is very sticky and has high plasticity; this situation has negatively affected plant development (Sari *et al*., 2003).

In a research conducted in the area of Kestel Lake, since lands are immature soils have recently reached terrestrial environment, their B horizon could not develop and they are lands with AC horizons. It has been stated that their colors as morphological distinctive features has generally values such as 2.5Y 4/2 and 5Y 4/3. It has been determined that clay textures are dominant in the soil, and the consistency properties of each soil series are very solid when they are dry, very stiff when they are moist and very sticky and very plastic when they are wet. On the other hand, it has been established that while structural structures in tillage depth, were strong moderate medium angular block, strong coarse angular block, strong moderate medium granular, strong coarse

granular; below tillage depth, they were found as massive for all the profiles. This has been explained by the fact that the territorial area is young and little or no affected by pedogenesis (Altunbaş & Sarı, 2011). In the study on the obtained areas as a result of drying process of Manay Lake, five soil types with significant differences in terms of physiography and soil relations have been selected in the agricultural land.

In these soils, they have found that there are four different physiographic units, including some physical, chemical and morphological features, alluvial fan, alluvial ridge, alluvial terrace and old lake basin, and five soil series with significant differences in terms of their characteristics and land use. It has been stated that there are high permeability depends on light and medium texture, holding low water and nutrient and gravelly interlayers that will prevent root growth on the soil on the alluvial fan and alluvial back physiographic units among the features that adversely affect the agricultural production potentials of the soil. It has been established that on the alluvial terraces,with high clay and lime content, depending on swelling and shrinkage due to vertical feature, possible physical damage to the plant root system and high clay and lime content, vertical feature, harmful drainage and high amount of changeable sodium in the old lake basins come to the fore. It has been emphasized that it is inevitable that there will be no successful results from the agricultural production practices to be done without considering these properties, as well as serious deterioration in soil properties and especially the occurrence of alkalinity problem in the old lake basins (Sarı *et al*., 2003).

Within this study, it has been searched that the morphological characteristics and horizon descriptions of the lands of Inekli, Azapli and Golbasi Lakes which are among the most significant wetlands of the Eastern Mediterranean region of Turkey.

## MATERIAL and METHOD

### Material

### Working area and features

Golbasi Lakes located within the borders of Adiyaman province, one of the most important wetlands of our country, has been determined as the research area.

Golbasi Lakes (Inekli-Azapli-Golbasi), which constitute the most important wetland between the Mediterranean Region and the Southeastern Anatolian Region, are located in the Golbasi Depression within the Eastern Anatolian Fault Zone.

The average elevation of the depression ditch in the Northeast and Southwest is 885 m. 1687 hectare area that includes the Golbasi, Inekli and Azapli Lakes has been declared as "Golbasi Lakes Nature Park" according to the National Parks Law no 2873 and has been protected and has been still continuing its feature as the wetland ecosystem (Master Plan, 2004).


**Figure 1.**The locations of the soil profiles opened in the ovary where Golbasi Lake is located

## Climate and hydrological features

In Golbasi Lake and around the lake, as if predominantly a terrestrial climate has been seen, partly the influence of the Mediterranean climate can be seen. The total precipitation amount is 680.3 mm according to the long-term data, while the lowest temperature is -14.4°C and the highest temperature is 45.3°C (Master Plan, 2004). As the hydrological characteristics of Golbasi Lake, there are varying changes in depth and surface of the lake due to annual and seasonal level of changes in the lake (Biricik, 1994). Golbasi (5 $km^2$), Azapli (4 $km^2$) and Inekli (3 $km^2$) are located in the depressions of Golbasi Lake depression bed. Golbasi is the biggest in terms of surface area and Inekli Lake is the smallest. Azapli Lake is located between these two lakes (Akdemir, 2004; Biricik, 1994).

## Geological features

In Adiyaman, there has been Lower Cretaceous Aged Limestone at the bottom and these lime stones are semi-crystallized and dolomitic. The geological formation existed in Cambrian and tertiary period, and Golbasi lake as narrow lake basin was changed in the Tertiary Period and it has come to the current state over time. It has been formed from marls and has been composed of clays and sandy beds. It has mostly arisen from main marl of the valley, schist, limestone, red and brown conglomerates.

Golbasi Lake, which has carstic-tectonic origin, is located in a depression ditch in the Northeast-Southwest direction (Akdemir, 2004). The pit area in which Golbasi, Azapli and Inekli Lakes is a depression with tectonic origin. This depression is on the Eastern Anatolian Fault Zone, which is one of the most important extension of tectonic states of the earth crust in Anatolia.

The Golbasi depression and the ophiolitic formations around it are located on the old basic site belonging to the Permo-Carboniferous. These lakes were affected by large-scale tectonic events and were later subject to erosion. Over time, the lake waters have been leveled and descended to sea level. Upper Cretaceous formations are common in Golbasi Lake and around it. Furthermore, in the west of Golbasi, Holocene alluvium extends northeast-southwest direction (Biricik, 1994). The GPS coordinates of the lands obtained from the wetlands of Golbasi Lakes, the altitudes from the sea level and the vegetation are shown in Table 1.

**Table 1.** Inekli Lake (I), Azaplı Lake (AZ), Golbasi Lake (GB) Coordinates of the profiles opened in the wetlands, elevations and vegetation

| Profile No | Coordinates | | Altitude | Vegetation |
|---|---|---|---|---|
| | E | N | m | |
| Inekli-1 | 37368120 | 4176930 | 901 | Weed |
| Inekli-2 | 37369158 | 4174285 | 884 | Wheat field |
| Inekli-3 | 37366942 | 4175759 | 882 | Weed |
| Inekli-4 | 37368025 | 4176701 | 877 | Reeds |
| Inekli-5 | 37368220 | 4176607 | 868 | Inside the natural site |
| Inekli-6 | 37369193 | 4172440 | 877 | Reeds |
| Inekli-7 | 37366827 | 4176358 | 892 | Attack |
| Azapli-1 | 37372527 | 4180376 | 883 | Plowed area |
| Azapli-2 | 37371149 | 4179536 | 870 | Alfalfa-meadows |
| Azapli-3 | 37374751 | 4179974 | 878 | Reeds end point |
| Azapli-4 | 37373229 | 4177539 | 893 | Wheat field |
| Azapli-Golbasi | 37377059 | 4181419 | 886 | Cultivated area |
| Golbasi-1 | 37380429 | 4184168 | 884 | Weed |

## Method

In research area, coordinates of sample points have been determined by means of GPS, with cross-sectioning the lake face and soil profiles have been opened. As far as possible, the main material has been tried to reach in opened profiles and horizon identification has been made. The geographical coordinates of the sample points have been determined by GPS. In Inekli, Azapli and Golbasi Lakes, thirteen soil profiles have been opened, 43 soil horizons have been obtained and the horizon has been identified by morphological examination according to the standard procedure of (Master Plan, 2004). Munsel color scale and 10 % hydrogen chloride (HCl) have been used for total calcium carbonate ($CaCO_3$) control, for determination of the color from the morphological characteristics of the soils. All horizons found in each profile have been examined and identified.

In accordance with principals which have been declared by Jackson (Jackson, 1962), soil samples have been taken and they have been dried in laboratory environment. After filtering them by 2 mm sieve, value of water saturation (Demiralay, 1993), soil reaction (Thomas, 1996) and electrical conductivity (Tuzuner, 1990) contents have been determined.

## RESULTS and DISCUSSION

The results obtained in this study carried out in order to search the morphological characteristics of the soils formed in the wetlands of the Inekli, Azapli and Golbasi Lakes in Eastern Mediterranean Region are shown in Table 2. When the table is examined, Inekli-1, Inekli-7, Azapli-1, Azapli-4 and Golbasi-1 profiles have been opened above soils which were arisen from main materials in Golbasi Lake and its surroundings; Inekli-2, Inekli-3, Inekli-4, Inekli-5, Inekli-6, Azapli-2, Azapli-3 and profiles between Azapli-Golbasi have been opened above the materials which have been transported to the lake area. It has been found that the average pH values of Inekli Lake soils is 7.66 and the total salt content value is 0.13 % and the pH values of Azapli is 7.95, total salinity value is 0.09 %. It has been determined that the pH values of Golbasi Lake soil is 8.01 and total salinity value is 0.05 %. It has been determined that horizons in profile Inekli-1 have a sequence of A1/A2/A3/C. It has been observed that when the soil is dry, its color is reddish; when it is moist, its color is dark brown. While the structure of the upper horizons is weak, small and granular, the lower horizon is determined as massive.

The profile soil is very rigid when it is dry; slightly sticky and plastic when it is wet. It has been observed that as the surface is turned from the horizon towards the lower horizons, the rate of sandiness and gravel increases. It has been observed that the Inekli-2 profile horizons have a

sequence of A/AC/C. The soil color has been determined as between reddish and brown when it is dry and it is very dark brown to dark reddish when it is moist. While the structure of the upper horizons is determined as weak, small and granular, the lower horizon is determined as medium, medium and granular. While soils are dry their structure is rigid, sticky and plastic when they are wet. Microbial activity is very dense in the surface horizon and this density disappears as it goes down to the lower horizons.It has been determined that the Inekli-3 profile horizons have a sequence of A/B/CB/C. While the soil color was dry, it was dark gray with a pale green color, while it was moist when it was between black and dark gray. The structure of the profile soil is defined as weak, small and semi-angular block. The profile soil is very rigid when it is dry; very sticky and very plastic when it is wet. It has been observed that plant root was seen very intense in the surface horizon. It has been determined that horizons in profile Inekli-4 have a sequence of A/AC/C. The soil color was light yellowish brown while it was dry and dark brown when it was damp. While the structure of the upper horizons is medium, small and granular, the lower horizon is determined as massive. While soils are dry their structure is very rigid, very sticky and very plastic when they are wet. On the surface horizon, the plant root was quite intense.It is found that the horizons in profile Inekli-5 have a sequence of Oa/Oe/C. The soil color was black when dry, and black and brown when it was moist. While the structure of the upper horizons is medium, small and granular, the lower horizon is determined as massive. While soils are dry their structure is very rigid, slightly sticky and slightly plastic when they are wet. Plant roots and mussel shells in the all horizons were quite intense. It has been determined that horizons in profile Inekli-6 have a sequence of A/AB/B/CB/C. When the soil color was dry, it was observed to vary between gray to light brown and moist to black to dark gray.

The structure of the upper horizons is weak, small and granular, and the lower horizon is massive. The soil is very hard when it is dry, very sticky and very plastic when wet. It is found that the horizons in profile Inekli-7 have a sequence of Ap/AC/C. The soil color was brown when it was dry, dark brown when it was moist.

The structure of the soil is weak, small and granular. The soil is loose when it is dry, very sticky and very plastic when wet. It has been determined that horizons in profile Azapli-1 have a sequence of A/AC/C. The soil color was light brown while it was dry and yellowish brown when it was moist. It is determined that the soil structure is weak, small and granular in the surface horizon while the middle and bottom horizons are massive. Soils vary from loose to hard while dry, slightly wet and slightly plastic. It has been observed that the Azapli-2 profile horizons have a sequence of A/AC/C. It was determined that the soil color changed from gray to light brown while it was dry and dark brown when it was moist. The soil structure is determined to be weak, small and granular in the surface horizons and massive in the bottom horizon. Soils vary from loose to hard while dry, very wet and very plastic. Rust spots were seen in the middle and lower horizons.It has been determined that horizons in profile Azapli-3have a sequence of Ap/A/AC/C. It was observed that the soil color changed between light gray and brown while it was dry and dark grayish brown when it was moist. Soil structure; Small, and block in the surface horizon, weak, small and granular in the middle horizons, and massive in the bottom horizon. The soil is very hard when it is dry, very sticky and very plastic when wet. In all the horizons there were quite intense mussel shells. It is found that the horizons in profile Azapli-4 have a sequence of A/AC/C. The soil color was light yellowish brown when dry and brown when moist. The soil structure was determined as weak, medium and semi-angular block in the surface horizon, weak, medium and granular in the middle horizons, and massive in the bottom horizon. The soils are very hard when dry, very sticky and very plastic when wet. Azapli-Golbasi profile opened between Azapli Lake and Golbasi Lake. It has been determined that horizons this profile has a sequence of A/AC/C. The soil color was brown when dry, dark brown when it was damp. The soil structure is weak, small and granular on the surface horizon, weak, middle and block on the middle horizon, weak, small and block on the bottom horizon. The soils are very hard when dry, very sticky and very plastic when wet. Golbasi-1 profile is opening in

the Golbasi Lake area. It is found that the horizons in profile has a sequence of A/C. The soil color was dark brown when dry, while it was found to be between reddish brown and damp. It is seen that the soil structure is massive. Soils are dry, loose, wet and not sticky and plastic.

Golbasi Lakes have been conserving the current natural situation of the lands of the lake face. It has been evaluated that the clay level is higher than other areas in Golbasi region where the natural conditions have been at least deteriorated as a sign that the natural state of water and thin matter transport is higher in the lost areas due to erosion. In other words, while the water in the area is draining through drainage channels, the materials in the form of clay are removed from the area. In this research, average saturation value of the lands of the Inekli, Azapli and Golbasi Lakes is 76.4 %, the average pH value is 7.78, and the total salt value averagely is 0.12 % have been estimated. It has been observed that in the C horizon of the Inekli-5 profile, the saturation and total salt value of the soil is high and the pH value is the lowest. Saturation and total salinity values have been found as the lowest in GB-1 profile, with the lowest percentage of silt and clay, and percentage of sand is ranked as the highest. The highest pH value of the soil has been seen in the Inekli-6 profile C horizon. When the average values of the Golbasi Lake soils are taken into consideration, it has been determined that pH is in the saline class of mild alkali and salinity class (Table 2). Soil reaction is important for plant growth, and pH has a major impact on the plant's intake of nutrients and the water solubility of toxic ions, and the activity of microorganisms (Yaras & Dasgan, 2012). The pH level of soil affects many physical, chemical and biological events that occur directly or indirectly in the soil (Foy, 1992).

**Table 2.**Morphological characteristics of the soil of research areas

| Horizon | Depth (cm) | Color (Dry, Humid) | | Structure | Consistency (Dry,Humid, Wet) | Qualifications features |
|---|---|---|---|---|---|---|
| | | Inekli Lake (Profile No: I-1) | | | | |
| A1 | 0-15 | D 10 YR6/3 | M 10 YR 3/3 | 1fgr | vh, fr, ss, np | cm, pb (1-2 mm) |
| A2 | 15-39 | D 10 YR 6/3 | M 10 YR 3/4 | 1fsbk | vh, fr, ns, sp | cm, pb (5-10 mm) |
| A3 | 39-69 | D 5 YR 5/6 | M 5 YR 3/4 | 1fgr | vh, fr, ss, sp | cm, pb (1-2 mm) |
| C | +69 | D 10 YR 5/6 | M 7,5 YR 4/6 | k | vh, fr, ss, sp | cm,pb |
| | | Inekli Lake (ProfileNo: I-2) | | | | |
| A | 0-17 | D 7,5 YR 4/4 | M 7,5 YR 3/3 | 1fgr | sh, fr, ss, sp | cm, ba (1-2 mm) |
| AC | 17-30 | D 5 YR 4/4 | M 5 YR 3/3 | 1fgr | so, fr, vs, vp | cm (1-2 mm) |
| C | +30 | D YR 4/3 | M 5 YR 3/4 | 2mgr | vh, fr, vs, vp | cm (2-5 mm) |
| | | Inekli Lake (ProfileNo: I-3) | | | | |
| A | 0-12 | D 2,5 Y 4/1 | M 2,5 Y 2,5/1 | 1fbk | vh, fr, ms, sp | cm, pr (5-10 mm) |
| B | 12-28 | D 2,5 Y 4/1 | M 2,5 Y 2,5/1 | 1fbk | vh, fi, vs, vp | cm (5-10 mm) |
| CB | 28-42 | D 5 Y 5/1 | M 5 Y 3/1 | 1fbk | vh, fi, vs, vp | cm (5-10 mm) |
| C | +42 | D 2,5 Y 6/3 | M 2,5 Y 4/4 | 1fbk | vh, fi, vs, vp | cm (5-10 mm) |
| | | Inekli Lake (ProfileNo: I-4) | | | | |
| A | 0-26 | D 2,5 Y 6/3 | M 10 YR 3/3 | 2fgr | vh, fr, ss, sp | cm, pr (1-2 mm) |
| AC | 26-60 | D 2,5 Y 6/4 | M 10 YR 3/4 | 2fgr | vh, fr, vs, vp | cm, pr (1-2 mm) |
| C | +60 | D 2,5 Y 6/3 | M 10 YR 3/1 | k | vh, fi, vs, vp | cm, pr (1-2 mm) |
| | | Inekli Lake (Profile No: I-5) | | | | |
| Oa | 0-10 | D 2,5 Y2,5/1 | M 10 YR 2/1 | 2fgr | vh, fi, ns, np | cm, pr, ms (1-2mm) |
| Oe | 10-18 | D 2,5 Y 6/3 | M 2,5 Y 4/3 | 2fgr | vh, fr, ss, sp | cm, pr, ms (1-2mm) |
| C | +18 | D 5 Y 2,5/2 | M 2,5 Y 2,5/1 | k | vh, fr, ss, sp | cm, ms |
| | | Inekli Lake (ProfileNo: I-6) | | | | |
| A | 0-20 | D 10 YR 5/1 | M 7,5YR 2,5/1 | 1fgr | vh, fr, vs, vp | cm (1-2 mm) |
| AB | 20-32 | D 10 YR 4/2 | M 10 YR 3/1 | 1fgr | vh, fr, vs, vp | cm (1-2 mm) |
| B | 32-42 | D 7,5 YR 5/1 | M 2,5 Y 2,5/1 | 1fgr | vh, fr, vs, vp | cm (1-2 mm) |
| CB | 42-60 | D 7,5 YR 5/1 | M 7,5 YR 3/1 | 1fgr | vh, fr, vs, vp | cm (1-2 mm) |
| C | +60 | D 2,5 Y 5/1 | M 2,5 Y 5/3 | k | vh, fr, vs, vp | cm |
| | | Inekli Lake (Profile No: I-7) | | | | |
| Ap | 0-17 | D 10 YR 6/4 | M 10 YR 3/6 | 1fgr | sh, fr, vs, mp | cm (1-2 mm) |
| AC | 17-27 | D 7,5 YR 4/4 | M 10 YR 3/3 | 1fgr | sh, fr, vs, vp | cm (1-2 mm) |
| C | +27 | D 7,5 YR 5/4 | M 7,5 YR 3/3 | 1fgr | vh, fi, vs, mp | cm (1-2 mm) |
| | | AzapliLake (Profile No: AZ-1) | | | | |
| A | 0-13 | D 10 YR 6/2 | M 10 YR 4/6 | 1fgr | sh, fr, ms,mp | cm (1-2 mm) |
| AC | 13-25 | D 10 YR 6/3 | M 10 YR 4/6 | k | h, fr, ms, mp | cm |
| C | +25 | D 2,5 Y 7/3 | M 10 YR 5/6 | k | vh, fi, ss, mp | cm |
| | | AzapliLake (Profile No: AZ-2) | | | | |
| A | 0-11 | D 2,5 Y 6/1 | M 2,5 Y 3/3 | 1fgr | sh, fr, ss, sp | cm (1-2 mm) |
| AC | 11-27 | D 2,5 Y 5/6 | M 2,5 Y 3/2 | 1fgr | sh, fr, vs, sp | cm (1-2 mm) |
| C | +27 | D 2,5 Y 6/6 | M 10 YR 3/4 | k | h, fr, vs, mp | cm |
| | | AzapliLake (Profile No: AZ-3) | | | | |
| Ap | 0-28 | D 2,5 Y 5/1 | M 2,5 Y 3/2 | 1fsbk | vh, fr, vs, vp | cm, ms (5-10 mm) |
| A | 28-42 | D 2,5 Y 7/1 | M 10 YR 4/2 | 1fgr | vh, fr, vs, vp | cm, ms (1-2 mm) |
| AC | 42-60 | D 2,5 Y 7/1 | M 2,5 Y 5/2 | 1fgr | vh, fr, vs, vp | cm, ms (1-2 mm) |
| C | +60 | D 5 Y 7/1 | M 2,5 Y 4/2 | k | vh, fi, vs, vp | cm, ms |
| | | AzapliLake (Profile No: AZ-4) | | | | |
| A | 0-16 | D 10 YR 6/4 | M 10 YR 4/3 | 1mbk | vh, fr, vs, vp | cm (10-20 mm) |
| AC | 16-32 | D 10 YR 5/4 | M 10 YR 4/3 | 1mgr | h, fr, vs, vp | cm (2-5 mm) |
| C | +32 | D 2,5 Y 6/3 | M 10 YR 4/4 | k | h, fr, vs, vp | cm |
| | | Azapli Lake- Golbasi Lake (Profile No: AZ-GB) | | | | |
| A | 0-21 | D 7,5 YR 4/2 | M 7,5 YR 3/3 | 1fgr | vh, fr, vs, vp | cm, pb (1-2 mm) |
| AC | 21-48 | D 7,5 YR 4/3 | M 7,5 YR 3/4 | 1msbk | vh, fr, vs, vp | cm, pb (10-20 mm) |
| C | +48 | D 7,5 YR 4/3 | M 7,5 YR 3/3 | 1fsbk | vh, fi, vs, vp | cm, pb (5-10 mm) |
| | | Golbasi Lake (Profile No: GB-1) | | | | |
| A | 0-70 | D 5 YR 3/3 | M 7,5 YR 3/3 | k | sh,fr,ns,np | cm, pb (1-2 mm) |
| C | +70 | D 2,5 YR 3/3 | M 2,5 YR 5/3 | k | sh,fr,ns,np | cm, pb |

Type of soil structure: sbk-round corner block, bk-corner block, pt-plate, gr-granular, k-massive, sg-monolithic structure; grade: 1-weak, 2-medium, 3-strong; class: f-small, m-medium, c-rude; consistency: so-soft, sh-a bit hard, h-hard, vh-very hard, fr-loose, fi-tight, ns-not sticky, ss-slightly sticky, ms-sticky, vs-very sticky, np-not plastic, sp-some plastic, mp-plastic, vp-very plastic, cm-carbonate masses, ba-biological activity, pb-pebbles, ms-mussel shells, pr-plant root (Soil Survey Manuel, 1993).

## CONCLUSION

In this study, the soil of the wetlands of Inekli, Azapli and Golbasi Lakes in the Eastern Mediterranean Region has been analyzed. In total, 13 soil profiles have been opened in the research area of the study, 43 soil horizons have been defined in order to determine the morphological characteristics of soil on the degraded soil samples which have been taken from these horizons.

The research area has been evaluated as a sign that the degradation of the natural state of the soil is the least, and that it is lower in the areas that conserve the natural state of transport of water and thin matter due to erosion. It has been stated that the soil color of the Inekli Lake is gray, reddish and brown when it is dried; when it moist, the color is black, dark brown and dark gray. The soil structure has been found as weak, small, granular in the upper horizons and massive in the lower horizons. It has been observed that the soils are very solid when it is dry; very sticky and very plastic when it is wet. It has been also stated that plant roots and microbial activity are concentrated in the surface horizons of this area; the color of Azapli Lake is light brown when the soil is dry; the color is dark brown when it is moist. It has been found that the structure is generally weak, small and granular while it is massive at lower horizons. It has been mentioned that when the soil of Azapli Lake is dry, it is rigid; when the soil wet, it is very sticky and very plastic.

It has been determined that the color of Golbasi Lake is dark brown when the soil is dry; when it is moist, color of soil is reddish brown and the structure of the soil is generally massive; when it is dry, it is loose; when it is wet and it is sticky and not plastic. It has been seen that the pH value and the Golbasi Lakes which has distortion rate and maintains the wetland characteristics of the current condition is mildly alkaline and the total value of salinity is alkaline. This leads to the formation of an idea that the pH and the salinity values of soils are related to the elevation of the researched areas. The salinity of the soil is less in the soil of Golbasi Lakes. It is related to the land use as well as the geological location, as the area land is related to less decomposition.

As a result of all the morphological analyzes carried out in this research, it has been concluded that the soil failure is low and the soil of Golbasi Lakes which have been conserved by the Ministry of Forestry and Water Affairs maintain their wetland characteristics at a better level than the other lake areas. It has been determined that there are many factors which limit the agricultural production in the soil as a result of drying process of the wetlands.

It has been obtained as a result of this study that these fields do not provide the desired economic contribution to the people living in the region with the gaining these lands to the agricultural production, on the contrary the benefits obtained from wetlands are loss.

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## REFERENCES

Abacı Bayan A.A. 2016. Soil characteristics, efficiency levels and problems of wetlands in the eastern mediterranean region. Kahramanmaraş Sutcu Imam University, Institute of Science, Department of Soil Science and Plant Nutrition, Doctorate thesis.

Akdemir İ. O. 2004. GolbasiIlcesinin (Adiyaman) Human and Economic Geography, PhD Thesis, Fırat University, Institute of Social Sciences, Geography Department.

Altunbaş S. Sarı M. 2011. Relations Between Some Physical Properties and Production Potentials of Soils Gained from Dried Kestel Lake, Akdeniz University, Journal of Agricultural Faculty, 24(1):61-65.

Biricik S.A. 1994. "Gölbaşı Depression". Turkish Geographic magazine Issue:29, İstanbul. pp:53-8.

Ministry of Environment, Right Environment for the year 2000. TBMM Environment Research Commission Report (10-15) Ankara.

Demiralay İ. 1993. Soil Physical Analysis. Atatürk University Agricultural Faculty Publications No: 143, pp: 131, Erzurum.

Foy C. D. 1992. Soil chemical factors limiting plant growth. In: J. L. Hatfield and B. A. Stewart (eds.), Limitations to Plant Root Growth. Adv. Soil Sci. 19:97-149.

Sari M., Altunbas S., Sonmez N. K. & Emrahoglu I. 2003. Properties and Potential Productivities of Old Manay Lake Area Soils on Different Physiographic Units. Akdeniz University Journal of Agricultural Faculty, 16: 7-17.

Sari M., Altunbas S. & Yildiran M. 2000. Determination of the Characteristics of the Wastes from the Kestel Lake Area Driven in the Lakes Region The Ministry of Environment, General Directorate of Environmental Protection Research Report, Ankara.

Soil Survey Manuel. 1993. Soil survey manual. USDA handbook No. 18. Washington, USA.

Master Plan. 2004. Ministry of Agriculture and Welfare, Project for the Preparation of Provincial Agriculture and Rural Development Master Plans, Adiyaman Agriculture Master Plan, December.

Thomas G.W. 1996. Soil pH and Acidity. pp:475-491. In D.L. Sparks (ed) Method of Soil Analysis: Chemical Methods. Part 3. SSSA, Madison, WI.

Tuzuner A. 1990. Soil and Water Analysis Laboratories Manual. Republic of Turkey Ministry of Agriculture, Forestry and Rural Affairs General Directorate of Rural Services. pp:21- 27.

Yaras K. & Dasgan H. Y.2012. The Effect of Micronize-Bentonite-Sulfur and Organic Matter Applied to Soil in Greenhouse Conditions on Soil pH, Tomato Plant Growth, Yield and Fruit Quality. Agricultural Science Research Journal 5 (1): 175-180.

Jackson M. L. 1992. Soil Chemical Analysis, Prentice-Hall Inc, 183.

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# A Software Development for Real Time Spray Control System in Herbicide Application

**Ömer Barış ÖZLÜOYMAK[1*], Ali BOLAT[2], Ali BAYAT[1], Emin GÜZEL[1]**

[1] Çukurova University, Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering, Adana/Turkey
[2] Republic of Turkey, Ministry of Food Agriculture and Livestock, Eastern Mediterranean Agricultural Research Institute, Adana/Turkey

*Corresponding Author: ozluoymak@cu.edu.tr

## Abstract

Advances in different technologies, such as high-resolution vision systems, innovative sensors and embedded computing systems, are finding direct application in agriculture. In precision farming, image analysis techniques can aid farmers in herbicide applications, and thus lower the risk of soil and water pollution by reducing the amount of chemicals applied. Optical sensors and computer vision, which can be used in automated weed detection and control spray systems, are being used in recent years extensively. A real-time auto tracking and determination system for weed detection and spray on/off were designed, built and set up in the laboratory at the Department of Agricultural Machinery and Technologies Engineering of Çukurova University. In this study; to get the target images, a web camera, mounted at a height of 50 cm above the target object was used. During the start of the weed tracking operation, the web camera captured images of the artificial weeds. Developed software, which could be reprogrammed and adjusted according to the user preference, was created by using LabVIEW. Weed coverage was determined from each image by using a "greenness method" in which the red, green, and blue intensities of each pixel were compared. The sprayer nozzle was turned 'on' or 'off' by using a data acquisition card and a relay card, depending on the green color pixels of weeds. The sprayer valve opened the nozzle when the camera detected the presence of weeds. Image processing performance of this system, in where nozzle and camera were mounted at a stationary position while weeds were on a movable belt, was tested at the different speeds of conveyor belt consisted of an inverter drive system and 3 phase 4 pole electric motor. The laboratory performance evolution revealed that the system could detect the weeds successfully and could be used to decrease the herbicide quantity.

**Keywords:** Image processing, LabVIEW, Machine vision, Weed detection

## INTRODUCTION

Weed control is a significant issue in agricultural crop production (Slaughter et al., 2008; Loni et al., 2014). Nowadays, there is a clear tendency of reducing the use of chemicals in agriculture. Numerous technologies have been developed trying to obtain safer agricultural products and lower environmental impacts.

The concept of precision agriculture provides a valuable framework to achieve this goal (Blasco et al., 2002; Tellaechea et al., 2008; Wan Ishak & Abdul Rahman, 2010; Sabanci & Aydin, 2017).

Especially, research on weed-sensing technologies, sensor fusion and selective crop management with herbicides or others control treatments have progressed significantly (Gonzalez-de-Soto et al., 2016). In addition to the technical realization of weed detection and site specific spraying, the economic benefit of precision weed management is important (Timmermann et al., 2003).

Detection and localization of weeds in the field, is one of the most challenging tasks for automatic weeding. Machine vision is a smart method that can be used to detect and track weeds. Tangwongkit et al. (2006) applied basic mechatronic and machine vision principles to develop a variable rate herbicide applicator to optimize the herbicide application rate corresponding to the amount of weeds by using Borland $C^{++}$ builder program. Sabanci & Aydin (2017) stated that the weeds on sugar beet fields were detected using image processing techniques and a model for variable level spraying liquid application was actualized. The spraying liquid was applied only to the detected plants instead of the whole field with the PLC controlled system. Yang et al. (2003) reported that a digital camera was used to take a series of grid-based images covering the soil between rows of corn in a field. Weed coverage was determined from each image using a "greenness method" in which the red, green, and blue intensities of each pixel were compared. Weed coverage and weed patchiness were estimated based on the percent of greenness area in the images. This information was used to create a weed map. Using weed coverage and weed patchiness as inputs, a fuzzy logic model was developed for use in determining site-specific herbicide application rates. MATLAB was used to develop the fuzzy logic algorithm. Sabancı & Aydın (2014) stated that the weeds between rows in sugar beet fields were determined by using image processing techniques and a model of variable level herbicide application was applied on them with precision spraying robot developed by MATLAB. Shirzadifar et al. (2013) reported that a real-time, site-specific, machine-vision based, inter-row patch herbicide application system was developed and evaluated. The image frames were processed by LabVIEW and MATLAB. The developed algorithm, based on weed coverage ratio and segmentation method for separating soil from plants, was chosen to be 2G-R-B. Wan Ishak & Abdul Rahman (2010) stated that a machine vision technology was developed to identify weeds in the outdoor environments. The automated sprayer system was developed using the combination of the electromechanical system, controllers, and the software. The graphical user interface (GUI) software, which was used to control the whole automatic system, was developed by Visual Basic programming. Tian (2002) reported that the smart sprayer, a local-vision-sensor-based precision chemical application system, was developed and tested. This research integrated a real-time machine vision sensing system and individual nozzle controlling device with a commercial map-driven-ready herbicide sprayer to create an intelligent sensing and spraying system. Jafari et al. (2006a) stated that the relation between three main components (red, green & blue) of the images, which constitute the true color of different plants have been extracted from image data using discriminant analysis.

300 digital images of sugar beet plants and seven types of common sugar beet weeds at different normal lighting conditions were used to provide enough information to feed the discriminant analysis procedure. Discriminant functions and their success rate in weed detection and segmentation of different plant species have been evaluated. MATLAB was used for algorithm development. The objectives of this study were to develop a real-time site-specific spraying system, based on machine vision technology by using LabVIEW and to evaluate the developed system under laboratory conditions.

## MATERIAL and METHOD

### Material

The weed management system was consisted of a camera, an image acquisition and processing system, a data acquisition device (National Instruments, NI USB-6009), a relay card, a solenoid valve, a spray nozzle and other necessary hardware. The site-specific herbicide application system was only developed for a single row. The image of artificial weed frames were captured by a webcam (Logitech C270) and sent to a laptop computer (Acer, Aspire, 4830TG) through a USB port. The imaging system equipment and working values are given in Table 1. LabVIEW was used as image processing and automation program.

**Table 1.** Equipment and working values of the imaging system

| amera | ensor | xel size | ısor size | l length | Iaximum esolution | orking istance | d of view |
|---|---|---|---|---|---|---|---|
| ɔgitech Webcam | CMOS | 2.8 µm (square) | 3.58 mm x 2.02 mm | 4 mm | 80 x 720 t the full frames | 500 mm | 60° |

Image processing performance of this system, in where nozzle and camera were mounted at a stationary position while weeds were on a conveyor belt, was tested at the different speeds of conveyor belt consisted of an inverter drive system and 3 phase 4 pole electric motor. The site-specific spraying system as a prototype developed in this study was shown in Figure 1.

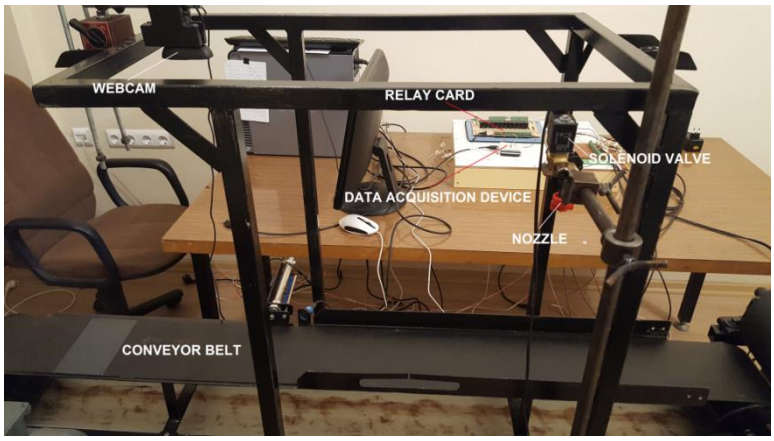


**Figure 1.** Prototype of real time spray control system developed in this study

## Method

Each pixel of the image has three color components, which are red (R), blue (B) and green (G). Since the image pixels corresponding to plant leaves have a greater G component as compared to R and B, the segmentation method for separating soil from plants was chosen to be "2G-R-B (greenness method)" (Jafari et al., 2006b; Shirzadifar et al., 2013).

The segmentation method for separating conveyor belt background from artificial weeds was chosen to be "2G-R-B" because artificial weed image pixels have a greater G component than R and B components (Figure 2).

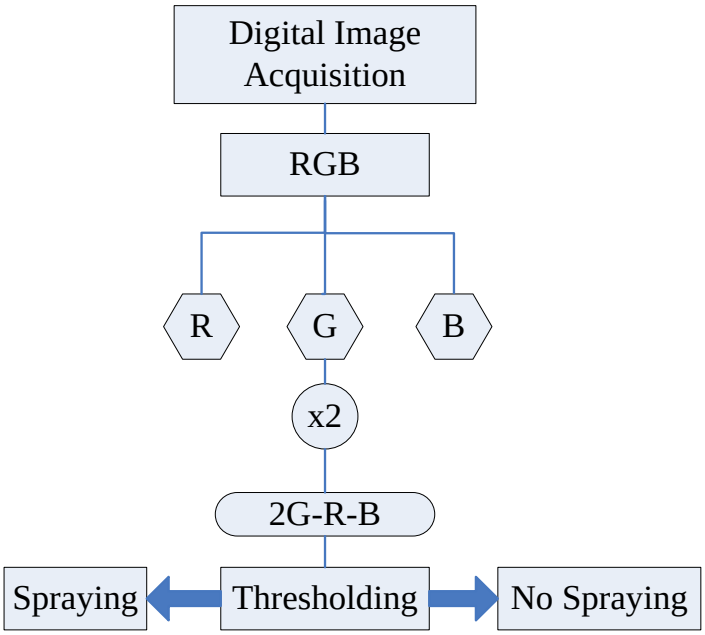


**Figure 2.** Flowchart of the image processing software

Artificial weed, which its pixels are larger than a preset threshold value, was tracked by the system. While it was moving on the conveyor belt, its x and y coordinate information were taken instantaneously. Spraying process was carried out by activating the solenoid valve while the artificial weed passing under the predefined coordinates in the system. The spraying continued according to the predefined coordinate values. The camera was mounted at a height of 50 cm above the artificial weed to get the images for experiments for which LabVIEW was used.

**Evaluation of the Image Processing Algorithm**

In this developed system, the artificial weed samples were separated into two categories as 'detected' and 'undetected' to evaluate the performance of the greenness method. It is very important that the system can distinguish the artificial weed and conveyor belt surface from each other. Correct determining and tracking has shown the performance of the image processing algorithm.

**Laboratory Tests**

The system was designed, built and set up in the chemical application laboratory at the Agricultural Machinery and Technologies Engineering Department of Çukurova University. It was tested to evaluate spraying accuracy of the sprayer at eleven conveyor speeds of 0.5, 0.75, 1, 1.25, 1.5, 1.75, 2, 2.25, 2.5, 2.75 and 3 km/h by using LabVIEW software program. The weed samples were being placed one by one manually on the conveyor belt. For each trial, a total of 100 artificial weed samples were used when making experiments.

Real-time auto tracking and spraying of artificial weed samples in the laboratory was shown in Figure 3. Only tap water was used as spraying liquid.


**Figure 3.** Real-time auto tracking and spraying of artificial weed sample in the laboratory

The system performance accuracy was calculated according to the conveyor belt speed for each test as shown in Equation 1. Each test was carried out three times to confirm the reliability of the system.

$$System\ Performance\ Accuracy\ (\%) = \frac{A}{B} \times 100 \qquad (1)$$

In where, A is the artificial weed samples sprayed by the sprayer nozzle and B is the total number of artificial weed samples.

## RESULTS and DISCUSSION

According to the results, artificial weed detection and tracking accuracy was determined by the greenness method. The effect of travel speed of the artificial weeds on conveyor belt was significant on system performance accuracy (Figure 4). The magnitude of spraying delay significantly increased by increasing travel speed. Several factors such as camera quality, solenoid valve response time, system pressure fluctuations resulting from sudden opening and closing of spray nozzles are considered to be responsible for the application delays observed in these tests. Reductions in the sprayed area could be attributed to the larger spraying delays at higher travel speeds. As shown in Figure 4, while identification and tracking efficiency of the system is %100 up to 2.75 km/h, maximum effective operating speed of the system has determined up to 1.5 km/h.

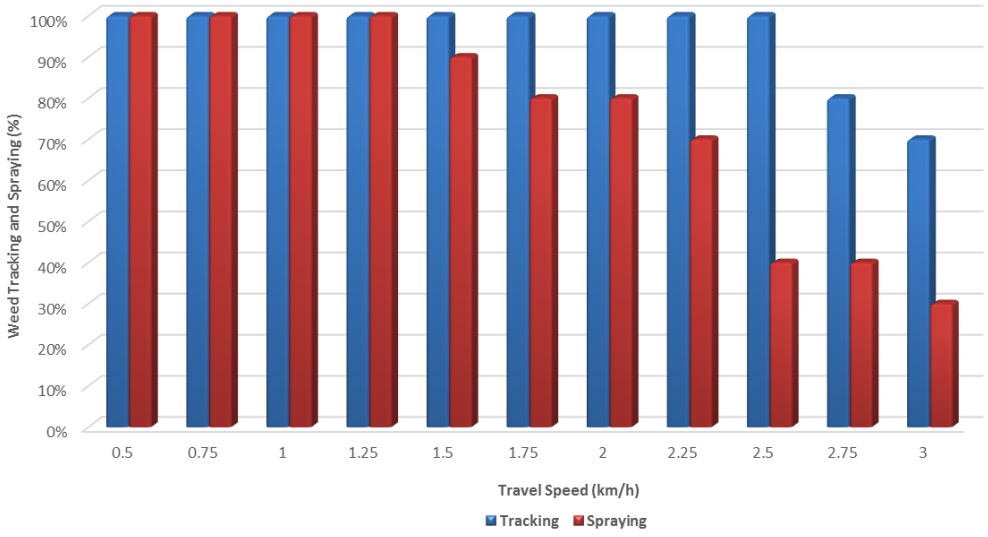


**Figure 4.** Test results of artificial weed tracking and spraying accuracy at various travel speeds

## CONCLUSION

A real time, machine-vision based, site-specific, inter-row spraying system prototype was developed and evaluated in herbicide application. LabVIEW software was used by developing image processing and automation algorithms for this system. The accuracy of the tracking and spraying performance increased at lower travel speeds. High tracking, detection and timing accuracies are the most important advantages of this system. The laboratory performance evolution showed that the proposed system could successfully detect the weeds and could be used to decrease the herbicide quantity. It is obvious that it will provide economics in the use of herbicides when compared to conventional spraying method in the eradication of weeds. Such a system will be both environmentally friendly and cost effective. This study will be a model for researchers, who aim to work on similar topics, and it will have a positive effect on system design in similar areas.

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## REFERENCES

Blasco J., Aleixos N., Roger J. M., Rabatel G. & Molto E. 2002. Robotic Weed Control Using Machine Vision, *Biosystems Engineering*, 83 (2), 149–157.

Gonzalez-de-Soto M., Emmi L., Perez-Ruiz M., Aguera J. & Gonzalez-de-Santos P. 2016. A utonomous Systems for Precise Spraying - Evaluation of A Robotised Patch Sprayer, *Biosystems Engineering*, 146, 165-182.

Jafari A., Mohtasebi S. S., Jahromi H. E. & Omid M. 2006a. Weed Detection in Sugar Beet Fields Using Machine Vision, *International Journal of Agriculture & Biology*, 8 (5), 602-605.

Jafari A., Mohtasebi S. S., Jahromi H. E. & Omid M. 2006b. Color Segmentation Scheme for Classifying Weeds from Sugar Beet Using Machine Vision, *Iranian Journal of Information Science & Technology*, 4 (1), 1-12.

Loni R., Loghavi M. & Jafari A. 2014. Design, Development and Evaluation of Targeted Discrete-Flame Weeding for Inter-Row Weed Control Using Machine Vision, *American Journal of Agricultural Science and Technology*, 2 (1), 17-30.

Sabancı K. & Aydın C. 2014. Image Processing Based Precision Spraying Robot, *Journal of Agricultural Sciences*, 20, 406-414.

Sabanci K. & Aydin C. 2017. Smart Robotic Weed Control System for Sugar Beet, *Journal of Agricultural Science and Technology*, 19, 73-83.

Shirzadifar A. M., Loghavi M. & Raoufat M. H. 2013. Development and Evaluation of a Real Time Site-Specific Inter-Row Weed Management System, *Iran Agricultural Research*, 32 (2), 39-54.

Slaughter D. C., Giles D. K. & Downey D. 2008. Autonomous Robotic Weed Control Systems: A Review, *Computers and Electronics in Agriculture*, 61, 63–78.

Tangwongkit R., Salokhe V. M. & Jayasuriya H. P. W. 2006. Development of a Real-Time, Variable Rate Herbicide Applicator Using Machine Vision for Between-Row Weeding of Sugarcane Fields, *Agricultural Engineering International: The CIGR Ejournal*, Manuscript PM 06 009, vol. 8.

Tellaechea A., Burgos-Artizzub X. P., Pajaresa G. & Ribeirob A. 2008. A Vision-Based Method for Weeds Identification through the Bayesian Decision Theory, *Pattern Recognition Society*, 41, 521-530.

Tian L. 2002. Development of a Sensor-Based Precision Herbicide Application System, *Computers and Electronics in Agriculture*, 36, 133-149.

Timmermann C., Gerhads R. & Kühbauch W. 2003. The Economic Impact of Site-Specific Weed Control, *Precision Agriculture*, 4, 249-260.

Wan Ishak W. I. & Abdul Rahman K. 2010. Software Development for Real-Time Weed Colour Analysis, *Pertanika Journal of Science & Technology*, 18 (2), 243-253.

Yang C., Prasher S. O., Landry J. & Ramaswamy H. S. 2003. Development of an Image Processing System and a Fuzzy Algorithm for Site-Specific Herbicide Applications, *Precision Agriculture*, 4, 5–18.

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# A New Approach in Management Against Plant Fungal Disease: Host Induced Gene Silencing

**Ozden SALMAN[1*], Nuh BOYRAZ[1]**

[1]Selcuk University, Faculty of Agriculture, Department of Plant Protection, Konya, TURKEY
*Corresponding author: ozdensalman@selcuk.edu.tr

## Abstract

Plant pathogenic fungi may cause crop losses that affect the world economy. Although one of the most effective ways to combat plant pathogens is a chemical control, alternative methods have become necessity as a result of environmental pollution and residue problems caused by pesticides used in agriculture. The mechanism of RNA interference (RNAi) has been developed to completely prevent or decrease the production of protein which is an expression of a specific gene. Due to the degeneracy of mRNA chain which is complementary of double-stranded RNA (dsRNA) entered into cells is prevented the production of protein. RNA silencing is very important for many organisms and microorganisms. This natural phenomenon can be exploited to control agronomically relevant plant diseases, based on the demonstration that *in vitro* feeding of dsRNA can signal Post transcriptional gene silencing (one of the RNA silencing methods) of target genes in various plant pests and pathogens, such as insects, nematodes and fungi. In other words, as well as determining a function of specific gene and developing of new plant various, RNA silencing was also begun to use for developing resistant plant varieties against biotic and abiotic factors by the suppression of gene expression. This biotechnological method, termed host-induced gene silencing (HIGS), has emerged as a promising alternative in plant protection because it combines high selectivity for the target organism with minimal side effects, as compared with chemical treatments. In recent years, the significant developments related to the use of HIGS in management against plant pathogenic fungi (*Puccinia striiformis* f.sp. *tritici*, *Blumeria graminis*, *Fusarium verticillioides* etc.) was obtained. In this review, it is mentioned from the mechanism of HIGS and studies related to the use against plant pathogenic fungi.

**Keywords:** dsRNA, HIGS, mRNA, PTGS, fungi, pathogen

## INTRODUCTION

Every year in the world, about 31-42% of the products produced due to diseases, harms and weeds are destroyed. When total loss is considered to be 36.5%, of which 14.1% is estimated from plant diseases, 10.2% from insects and 12.2% from foreign grasses (Agrios, 2005). Due to various problems such as rapid population growth, climatic changes, decreasing of water resources day by day, the need for food has become unable to supply. For this reason, the loss of crops caused by diseases, pests and weeds should be minimized. Therefore, the struggle is an inevitable. One of the most effective ways to combat plant pathogens is to use resistant varieties. The use of resistant varieties is at the forefront as an economic application.

However, it can take many years to obtain resistant varities with traditional breeding methods. For this reason, some researchers think that modern breeding methods (cloning, characterization, genetic transformation of resistance genes) can be used for such problems (İmriz et al. 2015). It is necessary to include some biotechnological applications such as gene silencing in

breeding programs in order to obtain high quality yields and to train disease resistant plants (Mmeka et al. 2014).

Gene silencing or gene inactivation which is a modern breeding method is occured in all eukaryotes from yeasts to mammals and it is a regulatory mechanism affecting gene expression (Gündoğdu & Çelik, 2009; Baumberger & Baulcombe, 2005). This mechanism is actually a natural process and is used to defend living organisms against foreign nucleic acid molecules (such as virus nucleic acids, transposons) (Gündoğdu & Çelik, 2009). Gene silencing is named differently depending on the species. It is termed co-suppression in plants, RNA interference (RNAi) in animals and quelling in *Neurospora crassa* (Duan et al. 2012). The phenomenon of gene silencing plays a role in cellular defense by protecting a plant or animal cell against the invasion of mobile genetic elements (Aras et al. 2015).

RNAi silencing is a natural event in eukaryotic organisms, and is also used in a variety of biotechnological systems to suppress the expression of endogenous genes by using synthetically produced non-coding RNAs (ncRNAs) which is 21-28 nt in length (Ruiz-Ferrer & Voinnet, 2009). In other words, RNAi silencing, a post transcriptional gene silencing (PTGS) mechanism, occurs in the presence of double-stranded (dsRNA) molecules that are complementary to a gene. In this way expression of the target gene is reduced or completely eliminated due to the messenger-RNA (mRNA) degrade (Armas-Tızapantzı & Montıel-Gonzalez, 2016). After all these developments, the interest of the scientific world has focused on RNAi, examining the functions of genes and determining the functions of genes for which we do not know how to function.

In Figure 1, RNAi mechanism is explained. During the RNAi mechanism, the sequence RNA complementary to the target mRNA binds to the significant sequence of the mRNA on the RISC factor (RNA-Induced Silencing Complex), a nuclease-active RNA multi-protein complex. The gene silencing is controlled by the RISC factor. The mRNA which interacts with the protein named 'Argounate' in the RISC factor is recognized and cleaved by the enzyme 'Dicer' which is a ribonuclease in the RNase -III family and thus the gene silencing occurs. The RNAi mechanism, in other words the gene silencing mechanism, is carried out by two types of molecules in eukaryotic organisms (Aras et al. 2015). Gene silencing is carried out by molecules called small RNA molecules, which are classified in different forms such as short interfering RNAs (siRNA), microRNAs (miRNAs), tRNA-derived RNA fragments (tRFs) and Piwi-interacting smallRNAs (piRNAs). In plants, siRNA and miRNA are the best known and studied species of these molecules (Cristiano & Dean, 2012).

Gene silencing mechanisms are based on the degradation of the target mRNA using siRNAs or shRNAs or the suppression of the translation of a specific mRNA using miRNAs (Keefe, 2013). Although miRNAs and siRNAs are very similar to each other, there are some differences between them.

While miRNA is responsible for regulating endogenous genes, siRNA is responsible for maintaining genomic integrity. miRNA precursor is single stranded RNA (single strand: ssRNAs) in hairpin structure and siRNAs precursor are long dsRNAs (Aras et al. 2015).

More recently, artificial microRNA technology has also emerged to block gene expression in plants (Ossowski et al. 2008). Artificial microRNA and siRNA technology is used to block gene expression in plants. In recent years, the use of vectors producing intron-containing hairpin RNA constructs in RNAi studies has increased in plants (Xu, 2010).

RNAi mechanism was first explored by Napoli and colleagues in 1990 by transferring genes encoding color to petunia. In this study, it was attempted to obtain darker purple petunias by promoting chalcone synthase (*chs*) genes. But the result is not as expected. As a result of silencing of the endogenous genes synthesizing the *chs* gene , petunias, which are either white or somewhat white or purple, are obtained instead of dark purple colored petunias (Napoli et al. 1990). This is called co-suppression or post transcriptional gene silencing (Armas-Tızapantzı & Montıel-Gonzalez, 2016). Fire and Mello (1998) injected dsRNA into the gonads of *Caenorhabditis elegans*, indicating that target genes were silenced.

RNA silencing is important for the investigation of the functions of genes. Suppression of gene expression through silencing of RNA has become important not only in researching gene function, but also in fighting plant diseases (Yin & Hulbert, 2015). In addition to viruses, organisms living in or interacting with the host, such as bacteria, nematodes, insects and parasitic plants, are also sensitive to small RNAs (sRNA) produced by the host and targeting foreign transcripts.

This method, called 'Host Induced Gene Silencing' (HIGS), has begun to be seen as a hope light in combating plant diseases. The genes chosen as targets for silencing are important genes responsible for pathogenic or virulence that are required for plant pathogens to survive. Recent articles published on the use of HIGS to control fungus infections are likely pioneer of more applications (Koch & Kogel, 2014).

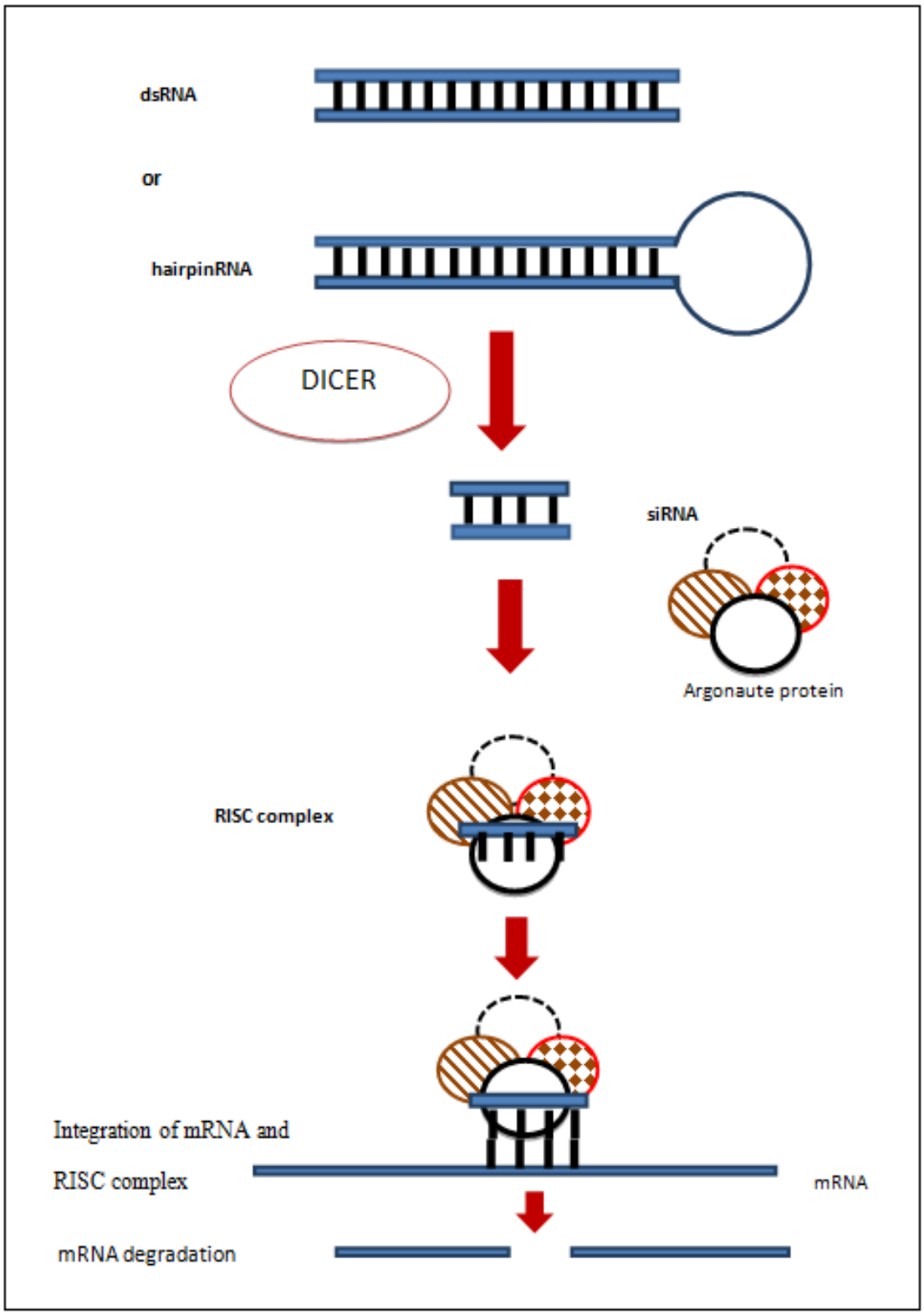


**Figure 1.** Mechanism of RNAi

RNAi against plant pathogenic fungi is used in two ways: (1) Directly induction of fungal genes by the host plant (HIGS) (2) indirectly induction of fungal genes by phytopathogenic viruses (VIGS) (Armas-Tızapantzı & Montıel-Gonzalez, 2016). We have focused on HIGS in this review.

## Mechanism of Host Induced Gene Silencing

HIGS is an improved form of 'Virus Induced Gene Silencing' (VIGS) that allows silencing the genes of plant pathogens. HIGS is obtained by transformation of plant embryos with a vector containing a fragment of the target gene from the pathogen or a dsRNA construct (Starkel, 2011). The structure that is formed after integration with the selected target gene-vector is called vector-target gene, HIGS structure. In Figure 2, HIGS structure in the infected plant cells combines with genomic DNA and it is transformed into dsRNA molecules in consequence of the transcription of the HIGS structure. The generated HIGS structure is transferred to the plant nucleus by different gene transductions such as electroporation or agroinfiltration. Once this structure is integrated with the genomic DNA, the resulting dsRNA structure is transferred to the cytoplasm with the aid of the Exportin-5 protein. HIGS dsRNA molecules are exported from plant cells when fungal infections. Target gene regions of fungal transcripts are silenced in fungal infections. (Cristiano & Dean, 2012). How the dsRNA is processed in host plants and how these constructs are sent to pathogens from plants has not yet been fully determined (Starkel, 2011).

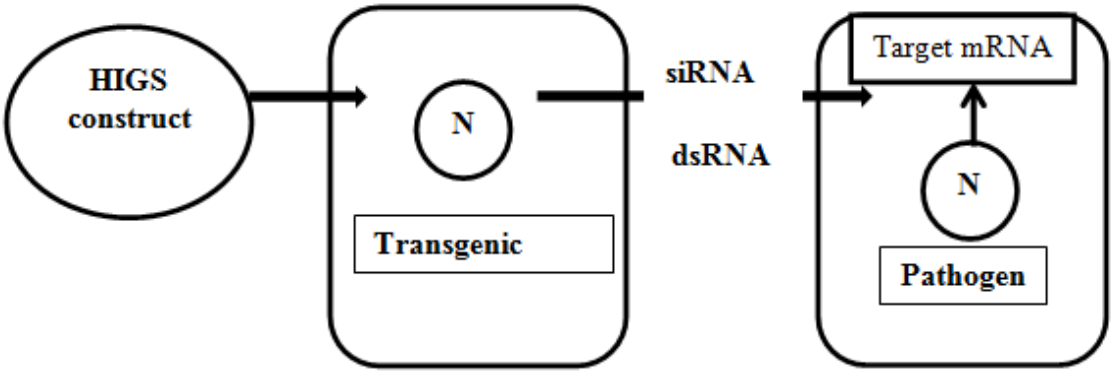


**Figure 2.** The mechanism of host induced gene silencing.

## The Applications Related to Control of Plant Pathogenic Fungal Disease by Host Induced Gene Silencing

The principle of HIGS is based on the silencing of the genes responsible for pathogenic infection and thereby is obtained resistant plants aganist pathogens (Song & Thomma, 2016). In this way, the host directly expresses the dsRNA-forming constructs corresponding to the genes selected as the target gene in the pathogen (Andradeab et al. 2015).

Non-coding RNA (nc-RNA) structures that provide silencing of RNA, such as; small interfering RNAs (siRNA) that pass through from host to filamentous organisms, on the contrary, the repressors which play a role in silencing and pass through from filamentous organisms to the host, microRNAs (miRNA) targeting components of natural defense systems (Baumberger & Baulcombe, 2015).

When the HIGS method is used against fungal pathogens, the fungal morphology changes, the growth inhibition in the plant and most importantly the virulence decrease (Weiberg et al. 2016).

The first findings of HIGS resistance in fungi are resistance to *Fusarium verticilloides* in tobacco and to *Blumeria graminis* in cereals (Tinoco et al. 2010). It has determined that the expression of siRNA and dsRNA in barley and wheat is complementary to mRNA during protein synthesis that are expression of important fungal genes (*GTF1*, *GTF2*, *Avrak1* and *Avra10*) that play a role in hausturium formation in powdery mildews. These results show that HIGS can be used to

control diseases in plants. One of the causes of disease in wheat and other cereals is also *Puccinia striiformis* f. sp. *tritici*. In another study conducted by Yin et al. (2011), *PSTha12J12*, *PSTha5A23*, *PSTha12H2*, *PSTha2A5* and *PSTha5A1* genes which play an important role haustorium formation of *Puccinia striiformis* f. sp. *tritici* have been selected as the target gene. In this study, it was also determined that the level of protein synthesis, which is encoded immediately after infecting the pathogen, also increases in wheat. As a result of this study, it was observed that these five genes identified as target genes were silenced (Yin et al, 2011). Starkel (2011) has shown that the *CTB2* gene responsible for virulence of *Cercospora beticola* which causes significant yield losses in sugar beet, could be used as a target gene in future HIGS studies. In a study by Zhang et al. (2012), HIGS technology have used to determine the function of genes homologous to the two subunits of calcineurin (*PsCNA1* and *PsCNB1*) responsible for the development and infection of *Puccinia striiformis* f. sp. *tritici*. As a result of this study, it has been determined that there is a temporal delay in sporulation and a decrease in hypha length, number, amount of spores and size of uredia (Zhang et al. 2012).

In 2010, Tinoco et al. demonstrated that HIGS could be used in phytopathogenic filamentous fungi by showing that *Fusarium verticillioides* has a structure (*hairpin (hp) GUS*) specifically silenced GUS transcripts in races producing *β-gulukoronidase* (*GUS*) during infection. Later, it has determined that the cytochrome lanesterol 14-α demethylase (*CYP51*) gene which is required for fungal ergasterol biosynthesis, affects negatively the growth and development of mycotoxin-producing *F. graminearum* (*Fg*) by silencing through HIGS (Koch et al. 2013). *CYP51A*, *CYP51B* and *CYP51C* genes are responsible for ergasterol biosynthesis of *Fg*. It has been found that 791 nucleotides-dsRNA (*CYP3RNA*) constructs complementary to these genes inhibit fungal growth and cause significant changes in fungal morphology. Consistent with these findings, expression of *CYP3-RNA* in both *Arabidopsis* and barley has rendered that susceptible plants resist to fungal infections. Microscopic analyses has revealed that mycelium formation is restricted in the inoculation zone of the leaves expressed *CYP3RNA* and that there is almost no fungal hyphae in barley seeds inoculated *Fg*. These results have shown that HIGS can be used as an effective method to silence selected fungal *CYP51* genes as target genes to prevent pathogen. Thus, fungal mycelium formation and plant infections can be prevented. Scientists believe that, with more extensive research in the future, it is necessary to evaluate the potential for RNA to pass instead of azole group fungicides.

n barley and wheat, dsRNAs targeting fungal glucanosyltransferase genes derived from an RNA structure (barley) or BSMV-derived VIGS (wheat) have been analyzed. As a result of the analyzes made, it has determined that the symptom of *B. graminis* in barley and the formation / development of haustoria in wheat decreased (Koch & Kogel, 2014).

It has limited use of pesticide and resistant variety aganist *Sclerotinia sclerotiorum* which is one of the necrotrophic fungi. An alternative to the development of necrotrophic fungal resistance is the use of the HIGS method. In this study, chitin synthase (*chs*), which plays a role in the synthesis of chitin, has determined as the target gene. A structure of hairpin RNA has transferred to tobacco to silence the chs gene. Compared to non-transgenic plants after 72 hours from inoculation, the severity of the disease in transgenic plants was found to decrease between 55.5%- 86.7%. In transgenic plants, the silencing of the fungal *chs* gene correlates positively with the amount of siRNA. With these studies, it has been shown that the expression of the internal genes in *S. sclerotiorum* can be prevented by HIGS and tolerant plants against this pathogen can be produced (Andradeab et al, 2015).

Resistant varieties to *P. infestans*, which causes significant yield losses, is used. However, the effectiveness of these genes is diminished because of the ability to develop new races against pathogen resistance. Jahan and colleagues evaluated the HIGS strategy by identifying siRNAs complementary to the selected target gene in order to reduce the infection severity of *Phytophthora infestans*. Hairpin RNA (hpRNA) was designed using the GFP marker gene. Then this structure was

applied to the potatoes. After 72 hours, the concentration of *P. infestans*-GFP in leaf samples of transgenic plants was reduced by 55-fold, when compared to wild-type potatoes. It is demonstrated that the RNA silencing construct is functional in the pathology and can target pathogen transcripts. G protein β-subunit (*PiFPB1*), cellulose synthetase (*PiCESA2*), pectinesterase (*PiPEC*) and glyceraldehyde 3-phosphate dehydrogenase (*PiGAPDH*) in *P. infestans* are important genes responsible for the infection process (Jahan et al. 2015). Furthermore, β subunit (*PiGPB1*), an important subunit of G protein, is responsible for sporangium formation and pathogenicity (Judelson & Blanco, 2005). The *hp-PiFPB1*, hp-*PiCESA2*, *hp-PiPEC* and *hp-PiGAPDH* constructs complementary to these gene sequences were tested using transgenic methods. At the end of this study, *hp-PiGPB1* largely prevented disease development. The sequence inoculated into the transgenic potato leaves silenced the target gene post transcriptionally. This study showed that the HIGS approach is functional against *P. infestans* but the success of result is highly dependent on the target gene. This finding has shown that HIGS can be used to fight this important plant disease (Jahan et al. 2015).

Govindarajulu et al. (2015) have selected the genes that play an important role in the infection of *Bremia lactucae* as the target gene and formed the transgenic lettuce plants that express the siRNA. It has been determined that transgenic plants expressing *B. lactucae* complementary constructs to the *HAM34* or *CES1* genes inhibit expression of these genes and significantly the sporulation of *B. lactucae* (Govindarajulu et al. 2015). HIGS technology is also used to control the formation of mycotoxins.

Aflatoxin is an important mycotoxin that causes cancer that contaminates products such as peanuts. nc-RNA fragments containing negative copies of aflatoxin-encoding genes in *Aspergillus flavus* (*aflR, aflS, aflep, aflC* / *pksA* / *pksL1, pes1*) were designed and used to silence these genes in peanuts. When compared to the control, it was determined that the levels of *Aflatoxin* $B_1$ and $B_2$ in mutant strains decreased by 60-100%.

The silencing of aflatoxin-encoding genes of *Aspergillus flavus* in peanut plants shows that HIGS may be an important pathway for the destruction of mycotoxin (Arias et. al., 2015). The most important disease of tall fescue (*Festuca arundinacea* Schreb.) used as forage and grass plant is brown patch, which is caused by *Rhizoctonia solani*. Zhou et al. (2016) have identified 4 target genes (including genes encoding RNA polymerase, importin beta-1 subunit, Cohesin complex subunit *Psm1*, and a ubiquitin E3 ligase) that play an important role in fungal infection to suppress infection and experimentally designed complementary siRNA constructs to these genes. As a result of inoculation studies, it has been determined that some plants are significantly resistant to *R. solani* and that there is no resistance in plants which is no RNAi accumulation (Zhou et al. 2016).

There are no resistant varieties against *Verticillium* wilt, which is one of the diseases caused by soil-derived fungi, in many plant species. For this reason, struggle with *Verticillium* disease is very difficult. Song and Thomma tried to determine whether they could suppress *Verticillium* wilt by silencing the genes responsible for virulence in tomato and *Arabidopsis* through HIGS. In conclusion, it was determined that HIGS against *V. dahliae* is also functional in tomato and *A. thalliana*, but the achievement changes depending on the selected target gene (Song & Thomma, 2016).

In recent years, a method based on the spraying of dsRNA and sRNA targeting genes responsible for pathogen infection has been studied. This method of struggle, called SIGS, is very important for plant protection because it is environmentally friendly (Wang & Jin, 2017). Wang and colleagues have chosen genes called *Bc-DCL1* and *Bc-DCL2*, which are responsible for pathogenicity and fungal growth, as target genes to prevent *Botrytis cinerea* infection causing gray mold infection in fruit and vegetables, and applied dsRNA molecules complementary to these genes to the fruit surface. With this study, it was determined that these molecules significantly decreased Botrytis cinerea infection up to 8 days (Wang et al. 2016). Thus, an important way for the use of environmentally friendly fungicides RNA has been covered.

## CONCLUSIONS

In recent years, HIGS has been emphasized in order to prevent yield losses and to cultivate durable plants. In studies up to now have shown that pathogen infection is partially or completely inhibited when appropriate target genes and nc-RNAs are used. However, no HIGS product has yet been commercialized against phytopathogenic fungi. We believe that the identification of genes that play a role in the virulence and pathogenicity of plant pathogens, the identification of silencing ncRNA constructs complementary to these genes and the increased work on applications where these constructs can be transferred more easily to plants will make these genes applicable in practice.

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## REFERENCES

Agrios, G. N. 2005. Plant pathology. 5nd edn, Elsevier Academic Press, California, USA.

Andradeab C. M., Tinocoa M. L. P., Rietha A. F., Maiaa F. C. O. & Aragao F. J. L. 2015. Host-induced gene silencing in the necrotrophic fungal pathogen. *Sclerotinia sclerotiorum. Plant Pathology, vol. 65, pp.626-632, 2016.*

*Aras S., Soydam-Aydın S., Fazlıoğlu A., Cansaran-Duman D., Büyük İ. & Derici K. 2015. Bitkilerde RNA interferans. Türk Hij. Den. Biyoloji Dergisi, 72(3), 255-262.*

Arias R. S., Dang P. M. & Sobolev V. S. 2015. RNAi-mediated control of aflatoxin in peanut: method to analyze mycotoxin production and transgene expression in the peanut/*Aspergillus* pathosystem. *J. Vis. Exp.* 106.

A. A*rmas-Tızapantzı & Mozntıel-Gonzalez* A. M. *2016. 'RNAi silencing: A tool for functional genomics research on fungi, Fungal Biology Reviews, vol. 30, pp. 91-100.*

Baumberger N. & Baulcombe D. 2005. *Arabidopsis* ARGONAUTE1 is an RNA Slicer that selectively recruits microRNAs and short interfering RNAs. *Proceedings of the National Academy of Sciences*, vol.102 no: 33., 11928-11933.

*Cristiano C. N. & Dean. R. A. 2012. Host-Induced Gene Silencing: a tool for understanding fungal host interaction and for developing novel disease control strategies. Molecular Plant Pathology, 13(5), 519-529.*

Duan, C. G., Wang C. H. & Guo H. S. 2012. Application of RNA silencing to plant disease resistance. *Silence*, 3,5.

Fire A., Xu, S., Montgomery M. K., Kostas S. A., Driver S. E. & Mello C. C. 1998. Potent and specific genetic interference by double-stranded RNA in *Caenorhabditis elegans*. *Nature* 391, 806-811.

Govindarajulu M., Epstein L., Wroblewski T. & Michelmore R. W. 2015. Host-Induced Gene Silencing Inhibits The Biotrophic Pathogen Causing Downy Mildew Of Lettuce. *Plant Biotechnology J.* 13(7), 875-83.

Gündoğdu R. & Çelik V. 2009. RNA inteferans (RNAi). Erciyes Üniversitesi *Fen Bilimleri Enstitüsü Dergisi* 25 (11-2), 34-47.

İmriz G., Özdemir F., Taş M. N., Ercan B., Topal İ. & Karaca M. S. 2015. Bitkilerde Fungal Ve Bakteriyel Hastalıklara Karşı Dayanıklılık Genleri Ve Sinyal İletimi. *Elektronik*

*Mikrobiyoloji Dergisi* TR (Eski adı: OrLab On-Line Mikrobiyoloji Dergisi) Cilt: 13 Sayı: 1 Sayfa: 12-27.

Jahan S. N., Asman A. K. M., Corcoran P., Fogelqvist J., Vetukuri R. R. & Dixelius C. 2015. Plant mediated gene silencing restricts growth of the potato late blight pathogen *Phytophthora infestans. Journal of Experimental Botany.*

Judelson H. S. & Blanco F. A, 'The spores of *Phytophthora*: weapons of the plant destroyer, *Nature Reviews Microbiology*, vol. 3, pp. 47-58.

Koch A., Kumar Neelendra., Weber L., Keller Harald., Imani J. & Kogel K. 2013. Host-induced gene silencing of cytochrome P450 lanosterol C14α-demethylase–encoding genes confers strong resistance to *Fusarium* species. *Proceedings of the National Academy of Sciences of the United States of America.*

Keefe E. P. O. 2016. siRNAs and shRNAs: Tools forProtein Knockdown by Gene Silencing.

Koch A. & Kogel K. H. 2014. New wind in the sails: improving the agronomic value of crop plants through RNAi-mediated gene silencing. *Plant Biotechnology Journal* vol. 12, pp. 821-831.

Mmeka E., Adesoye A., Ubaoji K. I. & Nwokoye A. B. 2014. Gene Silencing Technologies in Creating Resistance to Plant Diseases. *International Journal of Plant Breeding and Genetics* 8 (3), 100-120.

Ossowski S., Schwab R. & Weigel D. 2008. ''Gen silencing in plants using artificial microRNAs and other small RNAs, *Plant J.* vol. 53(4), pp.674-90.

Ruiz-Ferrer V. & Voinnet O. 2009. Roles of Plant small RNAs in Biotic Stress responses. *Ann. Rew. Plant Biol*. 60, pp. 485-510.

Song Y. & Thomma B. P. H. J. 2016. Host-Induced Gene Silencing Compromises *Verticillium* Wilt In Tomato And *Arabidopsis*. *Molecular Plant Pathology.*

Starkel C. 2011. Host Induced Gene Silencing - strategies for the improvement of resistance against *Cercospora beticola* in sugar beet (*B. vulgaris* L.) and against *Fusarium graminearum* in wheat (*T. aestivum* L.) and maize (*Z. mays* L.). Phd. Thesis, Berlin, Germany.

Tinoco M. L., Dias B. B., Dall'Astta R. C., Pamphile J. A. & Aragao F. J. 2010. *In vivo* trans-specific gene silencing in fungal cells by in planta expression of a double-stranded RNA. *BMC Biol* 31, 27.

Wang M., Weiberg A., Mao Lin F., Thomma B. P. H. J., Huang H. & Jin H. 2016. Bidirectional Cross-Kingdom Rnai And Fungal Uptake Of External Rnas Confer Plant Protection. *Nature Plants* 2, 16151.

Wang M. & Hailing. J. 2017. Spray-Induced Gene Silencing: a Powerful Innovative Strategy for Crop Protection. *Trends in Microbiology,* vol.25, no.1, pp. 4-6.

Weiberg A., Bellinger M. & Jin H. 2016. Conversations between kingdoms: small RNAs. *Curr Opin Biotechnol*. 32, 207–215.

Xu. G., Sui. N., Tang. Y., Xie. K., Lai. Y. & Liu. Y. 2010. One-Step, Zero-Background Ligation-Independent Cloning Intron-Containing Hairpin Rna Constructs For Rnai In Plants. *New Phytologis*t Vol. 187, Issue 1, Pp. 240-250.

Yin C., Jurgenson J.E. & Hulbert S.H. 2011. Development Of A Host-Induced Rnai System In The Wheat Stripe Rust Fungus *Puccinia Striiformis* F. Sp. *Tritici*. *Molecular Plant- Microbe Interactions,* Pp. 554-561.

Yin C. & Hulbert S. 2015. Host Induced Gene Silencing (HIGS), a Promising Strategy for Developing Disease Resistant Crops. *Gene Technology*.

Zhang H., Guo J., Voegele R. T., Zhang J., Duan Y., Luo H. & Kang Z. 2012. Functional Characterization of Calcineurin Homologs *PsCNA1/PsCNB1* in *Puccinia striiformis* f. sp. *tritici* Using a Host-Induced RNAi System. *Plos One Tenth Anniversary,* vol.7.

Zhou B., Bailey A., Niblett C. L. & Qu R. 2016. Control of brown patch (*Rhizoctonia solani*) in tall fescue (*Festuca arundinacea* Schreb.) by host induced gene silencing. *Plant Cell Reports* April, Volume 35, Issue 4, pp. 791-802

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# The Performance Assessment in Irrigation Systems: The Case of Turkey

**Mehmet Akif KALENDER[1*], Ramazan TOPAK[1]**

[1] Selcuk University, Faculty of Agriculture, Department of Farm Structures and Irrigation, Konya, Turkey

*Corresponding Author: makifkalender@selcuk.edu.tr

## Abstract

Water is an essential resource for human's live maintaining. Alongside it supplies people with daily needs, water is used for the purpose of agriculture, energy production, industry and tourism. The increase of population and industrialisation have caused both rise of present water consumption and contamination of present water resources. For this reason, water is among the resources should be used efficiently in the world. Water used in agriculture is considerably more than the other sectors use. Comparing with the developed and European countries, water percentage used in agriculture in Turkey is much more. It is known that water resources decreased and would decrease even more due to population increase, climate changes and unconscious uses. It is known that due to population increase, climate changes and unconscious uses, water resources decreased and will decrease even more. While Turkey is not among the countries suffered from water shortages, present water resources should be carefully used due to rapid population growth, pollution and the average annual precipitation lower than the world average and should be immediately taken the necessary precautions against contamination. Therefore, especially in agriculture, water must be used economical, conscious and in a planned way. Regarding this issue, one of the applications should be performed is performance assessments of irrigation. Studies about performance assessments of irrigation are carried out by the Irrigation Association to determine and take necessary measures the inabilities and problems on irrigation by evaluating of the present water potential in any area. In this review, performance assessments of irrigation studies carried out by Irrigation Associations were summarised.

**Keywords:** Assessment criteria, irrigation, irrigation associations, irrigation performance assessment, use of water, water resources

## INTRODUCTION

Water is an essential source for living creatures and it is important for plant development. Thus, importance of water in sense of agriculture is pretty much. The amount of freshwater bodies containing the large part of water use is 35 million $km^3$ which is 2,5 percent of total water presence. This water has been used 67-70 percent in agriculture, 22-23 percent in industry, 8-10 percent in water intended for human consumption. These rates in Turkey are as below; 72-75 percent in agriculture, 15-16 percent in water intended for human consumption, 10-12 percent in industry.

The average water consumption per human in the world is 800 $m^3$ in a year. About 20 percent of world population lack of adequate drinking water and 2,3 billion people can't reach the healthy water. The world average of the ratio of the population reaching healthy water to total population is about 82 percent. This ratio in Turkey is 93 percent. Average daily urban water consumption standard per human is 150 liter in the world, 111 liter in Turkey (DPT, 2007).

In consideration of above information, it is seen that in large of water has been used in agriculture. For this reason, planning and programming of water use in agriculture are crucial.

Because of population growth, climate change etc., the decrease of present water resources makes economical and convenient water use a current issue. Therefore, organizations providing control of the water fall is responsible on this subject. Organizations providing agricultural lands with water must make performance assessment of irrigation system and take some precautions.
When the performance level of irrigation and drainage projects is taken into consideration, increase of irrigated agricultural areas is expected to increase world's food production. But, the performance improvement on irrigation networks is needed because usable water and land sources are limited (Murry-Rust & Snellen, 1993)

In consequence of soil salinity and giving excessive water resulting from insensible irrigations, some areas become arid every year. In this respect, effective use of water and land sources and performance assessment in irrigation systems are of capital importance (Çakmak, 2002).

**PERFORMANCE ASSESSMENT and INDICATORS**

The performance of a system is its measured levels of achievement according to one or more parameters which are chosen as indicators (Bos et al., 2005). As to performance assessment in irrigation and drainage can be defined as the systematic observation, documentation and interpretation of activities related to irrigated agriculture with the objective of continuous improvement (Molden et al., 1998). Performance assessments have been made in the direction of various purposes. For example; developing system operation, evaluating processes intended strategic purposes, general situation of the system and interventions to system, comprehending better the factor determining the performance better, diagnosing the problems, comparing between system performance and others etc. Determination of performance assessment method depends on the purpose of assessed case (Abernethy, 1989). Performance assessments consist of some steps; Identification and planning, data collection, analysis, integration, action, monitoring and evaluation stages, respectively. Identification and planning stage is important and specifies the success of assessment in large measure. Content and characteristics of the data need for assessment is identified on this stage. Data collection stage is the core of assessment. Data need for assessment must be supplied from a confidential source and be complete. After analysis stage, to facilitate the integration and action stages, it is important to involve key players in the assessment process at the outset (Malano & Burton, 2001). Performance indicators are needed when irrigation performance has been assessed. These indicators have been identified by many researchers and give us information about effectiveness of performance. Performance indicators are a quantitative measure of irrigation situation which helps observing and assessing irrigation effectiveness (Alegre et al., 2000).

Malano and Burton (2001) revealed some performance indicators which recommended by IPTRID (International Programme for Technology and Research in Irrigation and Drainage). These indicators were showed under the titles of service delivery performance, financial, productive efficiency, environmental performance. Indicators are given in Table 1.

**Table 1.** Indicators of performance assessment

| | |
|---|---|
| **Service Delivery Performance** | annual volume of irrigation water delivery ($m^3$ $year^{-1}$)<br>al irrigation water delivery per unit command area ($m^3$ $ha^{-1}$)<br>al irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$)<br>system water delivery efficiency<br>al relative water supply<br>al relative irrigation supply<br>delivery capacity<br>ity of entitlement supply |
| **Financial** | ity of entitlement supply<br>ecovery ratio<br>enance cost to revenue ratio<br>MOM cost per unit area (US$ $ha^{-1}$)<br>cost per person employed on water delivery (US$ $person^{-1}$)<br>ıue collection performance<br>ng numbers per unit area (persons $ha^{-1}$)<br>ıge revenue per cubic metre of irrigation water supplied (US$ $m^{-3}$) |
| **Productive Efficiency** | gross annual agricultural production (tonnes)<br>annual value of agricultural production (US$)<br>ıt per unit serviced area (US$ $ha^{-1}$)<br>ıt per unit irrigated area (US$ $ha^{-1}$)<br>ıt per unit irrigation supply (US$ $m^{-3}$)<br>ıt per unit water consumed (US$ $m^{-3}$) |
| **Environmental Performance** | quality: Salinity (mmhos $cm^{-1}$)<br>quality: Biological (mg $litre^{-1}$)<br>quality: Chemical (mg $litre^{-1}$)<br>ıge depth to watertable (m)<br>ge in watertable depth over time (m)<br>alance (tonnes) |

Some studies concerned the performance assessment of Irrigation Associations and other irrigaton organizations in Turkey made by being used these performance indicators are in below;

Kapan (2010) aimed to assess the irrigation system performance of Asartepe irrigation put into operation in 1993 and assigned to Irrigation Association later between 2005 and 2008 years. The results related to this study are showed in Table 2. In consequence of this assessment, it was determined that annual irrigation water delivery per unit command area was 2181 - 6312 $m^3$ $ha^{-1}$, annual irrigation water delivery per unit irrigated area was 9546 – 14043 $m^3$ $ha^{-1}$, annual relative water supply was 0,25 – 1,17, cost recovery ratio was 7 - 73,9 percent and total annual value of agricultural production was 3163539 - 7217335 TL.

Eliçabuk (2016) carried out an irrigation performance assessment in Konya Gevrekli Irrigation Association between 2006 and 2012 years. The results related to this study are showed in Table 3. In consequence of this assessment, it was determined that annual irrigation water delivery per unit command area was 665 - 1301 $m^3$ $ha^{-1}$, annual irrigation water delivery per unit irrigated area was 2577 – 5273 $m^3$ $ha^{-1}$, annual relative water supply was 0,51 – 1,04, cost recovery ratio was 82,3 – 120,1 percent and total annual value of agricultural production was 21225000 – 38898000 TL.

Sönmezyıldız ve Çakmak (2013) aimed to assess irrigation performance of village of Beyazaltın in Eskişehir for the land consolidation. Results related to this study are showed in Table 4. In consequence of this assessment, it was determined that annual irrigation water delivery per unit command area was 4311,02 $m^3$ $ha^{-1}$, annual irrigation water delivery per unit irrigated area was

4311,02 $m^3$ $ha^{-1}$, annual relative water supply was 1,60, cost recovery ratio was 530 percent and total annual value of agricultural production was 9030000 TL.

Cin (2017) carried out an irrigation performance evaluation in Ankara Beypazarı Başören Irrigation Cooperative. Results related to this study are showed in Table 5. In consequence of this assessment, it was determined that annual irrigation water delivery per unit command area was 10542,8 $m^3$ $ha^{-1}$, annual irrigation water delivery per unit irrigated area was 14760 $m^3$ $ha^{-1}$, annual relative water supply was 1,98, cost recovery ratio was 50 percent and total annual value of agricultural production was 2378953 TL.

Nalbantoğlu (2016) aimed to benchmarking and assessment of irrigation performance of Akıncı Irrigation. Results related to this study are showed in Table 6. In consequence of this assessment, it was determined that annual irrigation water delivery per unit command area was 7,23 – 10,54 $m^3$ $ha^{-1}$, annual irrigation water delivery per unit irrigated area was 7,68 – 16,15 $m^3$ $ha^{-1}$, annual relative water supply was 1,55 – 1,98, cost recovery ratio was 56 – 172 percent and total annual value of agricultural production was 1021460 - 1561868 $.

**Table 2.** Performance indicators and results of study

| | Performance Indicators | Result |
|---|---|---|
| **Service Delivery Performance** | Annual irrigation water delivery per unit command area ($m^3$ $ha^{-1}$) | 2181 - 6312 |
| | Annual irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$) | 9546 - 14043 |
| | Annual relative water supply | 0,25 – 1,17 |
| **Financial** | Cost recovery ratio (%) | 7 – 73,9 |
| | Maintenance cost to revenue ratio (%) | 31,6 – 543,2 |
| | Total MOM cost per unit area (TL $ha^{-1}$) | 60,97 – 91,56 |
| | Total cost per person employed on water delivery (TL $person^{-1}$) | 3531,25 – 9487,50 |
| | Revenue collection performance (%) | 23 – 47 |
| | Staffing numbers per unit area (persons $ha^{-1}$) | 0,0053 |
| | Average revenue per cubic metre of irrigation water supplied (TL $m^{-3}$) | 0,004 – 0,009 |
| **Productive Efficiency** | Total annual value of agricultural production (TL) | 3163539 - 7217335 |
| | Output per unit serviced area (TL $ha^{-1}$) | 2108,96 – 4823,60 |
| | Output per unit irrigated area (TL $ha^{-1}$) | 7682,36 – 15839,25 |
| | Output per unit irrigation supply (TL $m^{-3}$) | 0,6118 – 1,5342 |
| | Output per unit water consumed (TL $m^{-3}$) | 5804 – 13951 |

**Table 3.** Performance indicators and results of study

| | Performance Indicators | Result |
|---|---|---|
| **Service Delivery Performance** | Annual irrigation water delivery per unit command area ($m^3$ $ha^{-1}$) | 665 – 1301 |
| | Annual irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$) | 2577 – 5273 |
| | Annual relative water supply | 0,51 – 1,04 |
| **Financial** | Cost recovery ratio (%) | 82,3 – 120,1 |
| | Maintenance cost to revenue ratio (%) | 32 – 51,8 |
| | Total MOM cost per unit area (TL $ha^{-1}$) | 89,93 – 165,31 |
| | Total cost per person employed on water delivery (TL $person^{-1}$) | 20975,68– 42296,78 |
| | Revenue collection performance (%) | 66,7 – 99,9 |
| | Staffing numbers per unit area (persons $ha^{-1}$) | 0,0018 – 0,0025 |
| **Productive Efficiency** | Total annual value of agricultural production (TL) | 21225000– 38898000 |
| | Output per unit serviced area (TL $ha^{-1}$) | 1679,2 – 3077,4 |
| | Output per unit irrigated area (TL $ha^{-1}$) | 6451,4– 11501,8 |
| | Output per unit irrigation supply (TL $m^{-3}$) | 1,474 – 3,814 |

**Table 4.** Performance indicators and results of study

| | Performance Indicators | Result |
|---|---|---|
| **Service Delivery Performance** | Annual irrigation water delivery per unit command area ($m^3$ $ha^{-1}$) | 4311,02 |
| | Annual irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$) | 4311,02 |
| | Annual relative water supply | 1,60 |
| **Financial** | Cost recovery ratio (%) | 530 |
| | Maintenance cost to revenue ratio (%) | 8 |
| | Total MOM cost per unit area (TL $ha^{-1}$) | 51,98 |
| | Total cost per person employed on water delivery (TL $person^{-1}$) | 10000 |
| | Revenue collection performance (%) | 100 |
| | Staffing numbers per unit area (persons $ha^{-1}$) | 0,002 |
| **Productive Efficiency** | Total annual value of agricultural production (TL) | 9030000 |
| | Output per unit serviced area (TL $ha^{-1}$) | 9386,69 |
| | Output per unit irrigated area (TL $ha^{-1}$) | 9386,69 |
| | Output per unit irrigation supply (TL $m^{-3}$) | 2,18 |
| | Output per unit water consumed (TL $ha^{-1}$) | 9236,65 |

**Table 5.** Performance indicators and results of study

| | Performance Indicators | Result |
|---|---|---|
| **Service Delivery Performance** | Annual irrigation water delivery per unit command area ($m^3$ $ha^{-1}$) | 10542,8 |
| | Annual irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$) | 14760 |
| | Annual relative water supply | 1,98 |
| **Financial** | Cost recovery ratio (%) | 50 |
| | Maintenance cost to revenue ratio (%) | 14 |
| | Total MOM cost per unit area (TL $ha^{-1}$) | 10 |
| | Revenue collection performance (%) | 100 |
| **Productive Efficiency** | Total annual value of agricultural production (TL) | 2378953 |
| | Output per unit serviced area (TL $ha^{-1}$) | 33985,04 |
| | Output per unit irrigated area (TL $ha^{-1}$) | 47579,06 |
| | Output per unit irrigation supply (TL $m^{-3}$) | 3,22 |
| | Output per unit water consumed (TL $ha^{-1}$) | 7,28 |

**Table 6.** Performance indicators and results of study

| | Performance Indicators | Result |
|---|---|---|
| **Service Delivery Performance** | Annual irrigation water delivery per unit command area ($m^3$ $ha^{-1}$) | 7,23 – 10,54 |
| | Annual irrigation water delivery per unit irrigated area ($m^3$ $ha^{-1}$) | 7,68 – 16,15 |
| | Annual relative water supply | 1,55 – 1,98 |
| **Financial** | Cost recovery ratio (%) | 56 – 172 |
| | Maintenance cost to revenue ratio (%) | 2,51 – 10,82 |
| | Total MOM cost per unit area (TL $ha^{-1}$) | 22,53 – 108,61 |
| | Total cost per person employed on water delivery (TL $person^{-1}$) | 1091,09 – 8658,84 |
| | Revenue collection performance (%) | 70 – 93 |
| | Staffing numbers per unit area (persons $ha^{-1}$) | 0,006 – 0,012 |
| | Average revenue per cubic metre of irrigation water supplied (TL $m^{-3}$) | 0,004 – 0,008 |
| **Productive Efficiency** | Total annual value of agricultural production (TL) | 1021460 - 1561868 |
| | Output per unit serviced area (TL $ha^{-1}$) | 364,81 – 557,81 |
| | Output per unit irrigated area (TL $ha^{-1}$) | 1454,29 – 2970,46 |
| | Output per unit irrigation supply (TL $m^{-3}$) | 0,107 – 0,110 |
| | Output per unit water consumed (TL $m^{-3}$) | 1350,69 – 2071,26 |

## CONCLUSIONS

As mentioned above, some case studies have been showing performances of some irrigation systems in Turkey. According to these studies, annual relative water supply has been generally high. That is to say, the water which is more than needed has entered to irrigation systems. Hereat, protection and using optimum of present water are essential.

Due to the fact that some irrigation organizations have an important position on irrigation management in Turkey, studies must be carried to use water properly and not to make farmers sufferer. Before water use directly, irrigation system performance must carried out and current situation analysis can be made. In this way, reasons of problems can be found and some precautions can be took.

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## REFERENCES

Abernethy C. L. 1989. Performance Criteria for Irrigation Systems, Conference on irrigation theory and practice, Southampton, England.

Alegre H., Hirnir W., Melo J. & y Parena, R. 2000. Performance indicators for water supply services, IWA Publishing, London.

Bos M. G., Burton M. A. & Molden D. J. 2005. Irrigation and Drainage Performance Assessment Practical Guidelines, International Irrigation Management Institute, Colombo, Sri Lanka.

Cakmak B. 2002. Assessment of Irrigation System Performance in Irrigation Associations, Kızılırmak Basin, KSU J. Science and Engineering, 5(2).

Cin S. 2017. Assessment of Irrigation Performance in Başoren Irrigation Cooperative Area of Beypazarı, Master Thesis, Ankara, Ankara University Graduate School of Natural and Applied Sciences Department of Farm Structures and Irrigation, Ankara.

Devlet Planlama Teşkilatı (State Planning Organization). 2007. Ninth Development Plan (2007-2013) webpage on Republic of Turkey Ministry of Finance, https://www.maliye.gov.tr/Lists/TabMenuIcerik/Attachments/106/9developmentplan.pdf/.

Elicabuk C. 2016. Performance Evaluation in Konya-Gevrekli Irrigation, Master Thesis, Selçuk University Graduate School of Natural and Applied Sciences Department of Farm Structures and Irrigation, Konya.

Kapan E. 2010. Benchmarking of Irrigation Performance in Asartepe Irrigation District, Master Thesis, Ankara University Graduate School of Natural and Applied Sciences Department of Farm Structures and Irrigation, Ankara.

Malano H. & Burton M. 2001. Guidelines for Benchmarking Performance in the Drainage Sector, International Programme for Technology and Research in Irrigation and Drainage IPTRID, FAO, Rome, Italy.

Molden D., Sakthivadivel R., Perry C. J., Fraiture C. & Kloezen W. H. 1998. Indicators for Comparing Performance of Irrigated Agricultural Systems, International Water Management Institute, Research Report 20, Colombo, Sri Lanka.

Murry-Rust D. H. & Snellen W. B. 1993. Irrigation System Performance Assessment and Diagnosis, International Irrigation Management Institute, Colombo, Sri Lanka.

Nalbantoglu G. 2006. Benchmarking of Irrigation Performance in Akıncı Irrigation District, Master Thesis, Ankara University Graduate School of Natural and Applied Sciences Department of Farm Structures and Irrigation, Ankara.

Sonmezyıldız E. & Cakmak B. 2013. Assessment of irrigation performance in land consolidation area of Eskişehir Beyazaltın village, Akdeniz University Mediterranean Agricultural Sciences, 26(1), 33-40.

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# Effects of Heat Stress on Dairy Cattle

**Elif SAHİN[1*], Nuh UGURLU[1]**

[1] Selcuk University, Faculty of Agriculture, Department of Farm Structures and Irrigations, Konya, TURKEY
*Corresponding Author: esahin@selcuk.edu.tr

## Abstract

In the design of dairy cattle shelters, behavior of the animals, climatic environmental factors and herd management have a significant impact. The most important function of dairy cattle barns to protect animals from unfavorable environmental conditions and to increase productivity will be achieved per animal providing with adequate housing environment for them. The most three important factors affecting yield in livestock raising are genetic, nutrition and environmental conditions, respectively. These three factors in order to achieve the highest level efficiency from the animals should be handled at the same time. Stress factors in dairy cattle are composed of structural, climatical and social environments. The stress resulting from the climatic environmental conditions occur due to changes of climatic values in the environment in which hosted of the animals. The most important parameter affecting the productivity of dairy cattle is climatical factors. Climatic environmental conditions consist of temperature, air velocity, relative humidity, solar radiation and light etc. parameters. The temperatures within the climatic environmental conditions are more important with regards to can exhibit normal behavior of the animals and their ability to sustain physiological activities. In dairy cattle, associated with rise above of optimum temperature zone of temperature will be broken heat balance of the body and the animals will enter the heat stress if this excess heat does not take away the of body. Shortly after the start of heat stress, declines will occur in milk yield and animal losses will be inevitable if necessary precautions are not taken. In this review, studies conducted related to in dairy cattle breeding how it should be of climatic environmental conditions suitable to animal behavior and effects on dairy cattle of heat stress were summarized.

**Keywords:** Behavior, critical temperatures, dairy cattle, heat stress, temperature, Temperature-Humidity Index (THI)

## INTRODUCTION

It is increasing the need for animal food products along with a growing world population .The need for animal foodstuffs will be possible by increasing the yield to be obtained from available animal existence while providing the environmental conditions required for animal welfare. In dairy cattle, the most important parameter indicating the productivity is annual milk production per animal.

Accordingly, the average milk production was 2.942 tons animals$^{-1}$ in Turkey while 9.9 tons animals$^{-1}$ in USA and 6.6 tons animals$^{-1}$ in European Countries (Anonymous, 2012). Although dairy cattle presence of Turkey was 20% of the European Countries average, milk production was 7% of that. Inappropriate environmental conditions, deficiency in nutrition and genetic structure can be showed among the major results of this (Uzal &Ugurlu, 2008).

Ugurlu & Uzal (2004) reported that first of all, to reach a high efficiency level of a living, namely the increase of productivity, was closely related stress factor in its the environment where in alive and stress consisting of tension resulting from various factors on live organism was slowing down the generative functions of the live and caused significant yield reduction. In dairy cattle barns, climatic environmental conditions should be checked to ensure animal welfare are temperature, relative humidity, air velocity, solar radiation and light. An animal must be in thermal equilibrium with its environment which radiation, air temperature, air velocity and humidity to maintain homeothermy (Kadzere et al. 2002). Animal surrounding environment influences the heat exchange between the environment and animals. Especially, environmental temperature is the most important factor in the regulation of the heat produced by the animal and in the maintenance of body temperature. To increase of animal production, kept at the desired level and the protection of the health of animals, in animal barns must be between certain limits in of temperature (Mutaf & Sönmez, 1984).

The animals entering heat stress will try to remove extreme heat in their bodies through the latent heat dissipation. Dairy cattle are trying to remove excess heat in the form of water vapor increasing respiration rate to latent heat dissipation. In the meantime, to live deal with excess heat issues is provided the reduction of heat generation stimulating the heat-sensing center in the brain. To reduce of heat production, the live significantly reduces feed intake and occurs lack of appetite. Yield decreases with a reduction in feed intake.

In the increase of animal production three main factors: genetic structure, care-feeding and environmental conditions. To increase of productivity in animal production, cattle breeds with high efficiency genetically should be developed and it must be made of the breeding of this race. Environmental conditions, because it is the factors that regulate living comfort at the climatical, structural and social issues in housing environment of the animals, constitute an integral tripartite structure with genetic structure and nutrition in increasing livestock production (Uzal & Ugurlu, 2009).

**Proper Temperature Intervals in Dairy Cattle**

The income derived from livestock in order to increase within economical constraints, relations with animal husbandry of climate factors need to understand and evaluate. While investigating effects on the animals of climatic factors, before each should be considered separately, then it must also be focused on their jointly effects. Besides the influences on yield of climatic factors, there are also indirectly effects on disease, care and nutrition.

These effects constitute different results in various animal species and in different races within the same species (Atasever et al. 2004). Heat stress, as directly or indirectly, affects on feed intake, body temperature, maintenance needs, milk yield, reproduction performance, behavior and illness rate of the animals (Thatchet, 1974; Cook et al. 2007; Tucker et al. 2007; Rhoads et al. 2009). In one study, Shinde and Teneja (1986) reported that Between milk yield and climatical factors was a usually negative and significant correlation and they stating that temperature and humidity affected animals and there should be between 25 °C and 7 °C of comfort zone (optimal temperature interval) for maximum milk yield.

The body temperature of dairy cows varies between 38-39.3 °C, with an average of 38.6 °C. The optimum temperature for most farm animals ranges from 10-20 °C. Even in high humidity conditions, cattle produce well in temperatures between 4-24 °C.

So long as it's not very sudden temperature fluctuations, very low temperatures, such as -10 °C, have very little effect. When the temperature exceeds 25 °C, there is a drop in milk production. This decrease can be up to 50% at temperatures of 32 °C and higher. However, the appropriate temperature for cattle adapted to mild climates ranges from 15 to 27 °C and milk production begins to fall when temperatures rise above 35 °C (FAO, 2016). Heat stress occurs when average temperatures are higher than the temperature. Lactating dairy cattle prefer to average temperatures between 5-25 $^{0}$C in optimum temperature zone (Roenfeldt, 1998). At ambient temperature above 26 $^{0}$C, cattle are forced to cool their bodies and enter heat stress (Kadzere et al. 2002).

Reactions of the cattle to temperatures above optimal temperature zone are different (Kadzere et al. 2002). These contain respiration increased rates and rectal temperature (Omar, 1996), raised panting and drooling and reduced heart rates (Blazquez, 1994) besides decreased milk production (Keown & Grant, 1997) and feed intake (Rhoads et al. 2004). Appropriate temperature for cattle examined by many researchers is the suitable temperatures between 0-24 °C temperature values and is the optimum temperatures between 7-15 °C temperature values (Demir, 1992). Comfort zone temperature contains a limited range and temperature values remaining within this region is considered as optimum temperatures (Ekmekyapar & Okuroğlu, 1984).

Optimum temperature limits for dairy cattle is 10–20 °C (Webster, 1994). Although suitable temperature values for cattle is 4-24 °C, the optimum temperature values 10-15 °C and the optimum temperature lower limit 7 °C, in temperatures above 24 °C begins to decrease milk production in dairy cattle. Indeed, associated with rise to 35 $^{0}$C of temperature reduce by 50% milk production (Ekmekyapar, 1991). Optimum, suitable, lower and upper critical temperatures in cattle are given in Table 1.

Water loss by evaporation from the skin increases in temperatures above 20 (Berman, 1968). Upper critical temperature for dairy cattle, regardless of their milk production or previous climate adaptation is 25-26 degrees (Berman et al. 1985). When the heat which cannot be removed from the body exceeds heat loss capacity by evaporation, body temperature increases and animals die from hyperthermia if unchecked (Kadzere et al. 2002).

**Table 1.** Optimum, suitable, lower and upper critical temperature values to cattle

| **Lower Critical Temperatures ($^0$C)** | | **Optimum Temperatures ($^0$C)** | | **Suitable Temperatures ($^0$C)** | **Upper Critical Temperatures ($^0$C)** | |
|---|---|---|---|---|---|---|
| -10 (FAO, 2016) | -15 (WMO, 1989) | 7-25 (Shinde & Teneja, 1986) | 10 (Maton et al. 1985) | 0-24 (Demir, 1992) | 25-26 (Berman et al. 1985; NRC, 1989) | >25 (Sainsbury & Sainsbury, 1988; FAO, 2016) |
| -12 (to Holstein, Brown Swiss)<br>-1(to Jersey)<br>(Yeck & Stewart, 1959; Young, 1981) | - 14 (pregnant and dry)<br>-25 (in the peak period of lactation)<br>(Radostits & Blood, 1985) | 10-20<br>(Sainsbury & Sainsbury, 1988; Webster, 1994 FAO, 2016) | 10-15<br>(Sainsbury, 1974; Balaban & Şen, 1988; Ekmekyapar, 1991; Okuroğlu & Yağanoğlu, 1993; Anonymous, 2015) | 5-25<br>(Roenfeldt, 1998; Anonymous, 2015) | >21 (to higly productive and elderly animals)<br>(Johnson,1987; Doležal, 2004) | 21-27<br>(Blackshaw & Blackshaw, 1994; Doležal et al. 2004) |
| -10 (draught free)<br>2 (2 ms$^{-1}$ wind speed)<br>(Noton, 1982) | -26 (0.2 ms$^{-1}$ wind speed)<br>-13 (2 ms$^{-1}$ wind speed)<br>(Webster, 1981) | 7-15<br>(Demir, 1992; Yüksel, 1993) | 0-20<br>(Brody, 1955) | 4-24<br>(Ekmekyapar, 1991; FAO, 2016,9 | >26 (Kadzere et al. 2002)<br>27 (WMO, 1989) | 25 (Radostits, and Blood, 1985)<br>25-27 (NRC, 1981) |
| -6<br>(Sainsbury & Sainsbury, 1988) | <(-5) or <(-10)<br>(Williams, 1959) | 5-15<br>(WMO, 1989) | | 0-20<br>(Wathes et al. 1983) | >24 (Ekmekyapar, 1991; West, 2003) | 21-25 (to Jersey)<br>30-32 (to Brown Swiss)<br>(Brody, 1955) |
| <(-7) (Sainsbury, 1974) | | | | | > 27 (Brouček, 1997) | 28 (Wathes et al. 1983) |

Developed indexes to determine the level of heat stress is called as THI (Temperature-Humidity Index). THI is determined with various formulas developed of researches by measuring dry bulb, wet bulb, dew point temperatures and relative humidity of air and the dairy cattle is confirmed whether the heat stress or not. According to various researchers, THI is determined using the following formulas.

$THI = (0.15 * T_{db} + 0.85\ T_{wb}) * 1.8 + 32$, (Bianca, 1962) (1)

$THI = (0.35 * T_{db} + 0.65\ T_{wb}) * 1.8 + 32$, (Bianca, 1962) (2)

$THI = (1.8 * T_{db} + 32) - [(0.55 - 0.0055 * RH) * (1.8 * T_{db} - 26.8)]$, (NRC, 1971) (3)

$THI = T_{db} + 0.36 * T_{dp} + 41.2$, (Yousef, 1985) (4)

$THI = 0.72 * (W + D) + 40.6$, (Kadzere et al. 2002) (5)

$THI = t_{ba} + 0.36 * t_{pr} + 41.2$, (ASABE, 2006) (6)

$THI = (0.8 * T_{db}) + [(RH / 100) * (T_{db} - 14.4)] + 46.4$, (Mader et al. 2006) (7)

$THI = (1.8 * T + 32) - ((0.55 - 0.0055 * RH * (1.8 * T - 26))$, (Titto et al. 2011) (8)

In these formulas, Tdb, $t_{ba}$ and D are dry bulb temperature ($^0$C); Twb and W are wet bulb temperature ($^0$C); $T_{dp}$ and $t_{pr}$ are dew point temperature ($^0$C); RH is relative humidity (%).

Gantner et al. (2011) point out that the THI is 72, which corresponds to a temperature of 22 $^0$C at 100% relative humidity, 25 $^0$C at 50% relative humidity or 28 $^0$C at 20% relative humidity and milk production at higher THI values than 72 is affected by heat stress. Milk yield of dairy cattle decrease by 0.3 kg per animal compared to each unit increase of THI value (Gantner et al. 2011). Similarly, milk yields of cows decreased by 1.8 kg along with per unit increment of average ambient temperature (Johnson, 1963; Smith et al. 2012).

Zimbelman et al. (2009) reported that decrease in the level of milk production started out 65 and over of the THI value. THI is used to measure thermal comfort in most studies and for dairy cows generally considered to be the upper limit THI ≥72. Milk yield of cows on this level generally reduce due to the heat stress (Igono et al. 1992; Ravagnolo & Misztal, 2002; Gaughan et al. 2008; Armstrong, 1994). THI values low from 71comfort zone, 72-79 mild stress, 80-90 average stress and values greater than 90 were defined as extreme stress zone. Furthermore, Kadzere et al. (2002) reported that THI values of 70 or less were comfortable, 75-78 stressful, and lactating dairy cattle were not to maintain the body heat balance in values greater than 78 and this situation caused extreme stress. The effects of THI on stress and behavior in dairy cattle are shown in Figure 1 and Table 2.

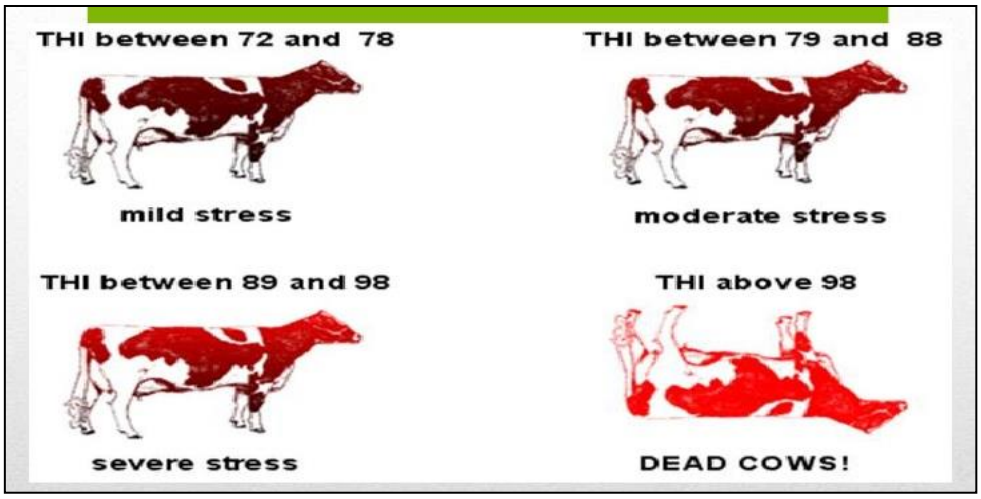



**Figure 1.** The effects of the temperature-humidity index in dairy cattle (Anonymous, 2016a)

**Table 2.** Effect of heat stress on dairy cattle (Anonymous, 2016b)

| THI | Stress Level | Comments |
|---|---|---|
| **<72** | None | - |
| **72-79** | Mild | ❖ Dairy cows will adjust by seeking shade, increasing respiration rate and dilation of the blood vessels.<br>❖ The effect on milk production will be minimal. |
| **80-89** | Moderate | ❖ Both saliva production and respiration rate will increase.<br>❖ Feed intake may be depressed and water consumption will increase.<br>❖ There will be an increase in body temperature.<br>❖ Milk production and reproduction will be decreased. |
| **90-98** | Severe | ❖ Cows will become very uncomfortable due to high body temperature, rapid respiration (panting) and excessive saliva production.<br>❖ Milk production and reproduction will be markedly decreased. |
| **>98** | Danger | ❖ Potential cow deaths can occur. |

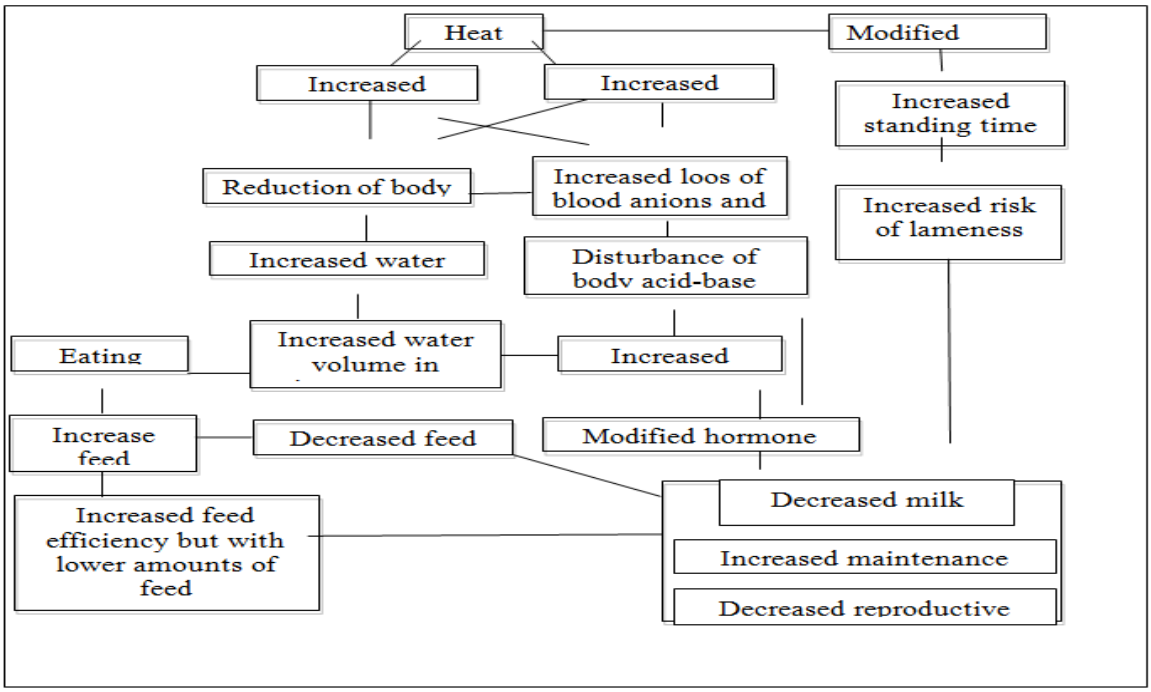
## Effect on Behavior of Heat Stress

Normal behavior of dairy cows exposed to heat stress varies. In particular, standing behavior is a behavior that in hot environmental conditions should be monitored for dairy cattle (Cook et al. 2007; Legrand et al. 2011). In lactating cows begins to decline feed intake at average 25-26 $^0$C temperatures and this fall is drops more quickly in temperatures above 30 $^0$C (NRC, 1989). Bandaranayaka and Holmes (1976) stated that fat and protein content of milk decreased at 30 $^0$C when feed intake was kept at the both temperatures by working with two pairs Jersey cow exposed to either 15 $^0$C or 30 $^0$C air temperature.

In a study, Schneider et al. (1988) reported that dairy cattle in heat stress consumed less feed (13.6 vs. 18.4 kg $day^{-1}$), more water (86.0 vs. 81.9 lt $day^{-1}$) and produced less milk (16.5 vs. 20.0 kg $day^{-1}$) than cows in a suitable temperature zone. Dry matter intake and eating activity frequency all day long reduce in heat stress conditions. This activities increase at the evening, night and early morning hour (Schneider et al. 1988). Rhoads et al. (2004) stated that their reduced feed intake when cows exposed to heat stress and simultaneously care needs increased due to the activation of the temperature regulating system, milk production declined 2 days after heat stress and feed intake decreased within 1 day after start of heat stress. According to Collier et al. (1981), maximum decrease in milk yield during heat stress occurs within 48 hours after the onset of stress.

When ambient temperature rises above 25-26 °C, decrease in feed consumption and mild yield occurs and when temperature exceeds 32 °C, milk yield reduce at 3-20% rates (Keown & Grant, 1997). Cows with the increase of the heat load spend more time in the shade and they spend less time to lying (Ansell, 1981; Schütz et al. 2010). Rates of cattle rested in upright position or performed rumination is linearly increasing as temperature increases (Shultz, 1984). By cows standing, maximize evaporation from the body surface and benefit from convection derive from wind (Frazzi et al. 2000). With an increasing average temperature or solar radiation, cattle are more likely to seek shades or other cooling structures (Atrian & Shahryar, 2012). General effects of heat stress in dairy cattle are given in Table 3.

**Table 3.** Schematic depiction of the general effects of heat stress in dairy cattle, (Atrian & Shahryar, 2012)



## CONCLUSIONS

When a general assessment is made, it is important that the shelters do not create climatic stress on the livings. In order to achieve this condition, free systems that allow the cattle to use different areas within the structure at different times are more advantageous. In order to protect cattle from the adverse effects of high temperatures, especially areas where will occur sufficient shadow and airflow should be provided.

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## REFERENCES

Anonymous, 2012. http://www.ulusalsutkonseyi.org.tr (accessed 04 May 2015)

Anonymous, 2015b. http://www.zootekni.org.tr (accessed 30 April 2015)

Anonymous, 2015c. Hayvan Barınakları. http://www.fidantarımsaldanismanlik.com (accessed 30 April 2015)

Anonymous, 2016a. Dairy Cattle Heat Stress. http://www.slideshare.net/thermalaid1/dairy-cattle-powerpoint (accessed 23 August 2016)

Anonymous, 2016b. Climate Change Impact on Dairy Cattle. http://www.uvm.edu (22 June 2016)

Ansell R. H. 1981. Extreme Heat Stress in Dairy Cattle and its Alleviation: A Case Report. In: Clark JA (ed.), Environmental Aspects of Housing for Animal Production, Buttherworths, London, pp. 285-306.

Armstrong D. V. 1994. Heat Stress İnteraction With Shade And Cooling. *J. Dairy Sci*. 77, 2044–2050.

ASABE 2006 Standards 53rd Edition, Design of Ventilation Systems for Poultry and Livestock Shelters, in ASAE EP270.5 FEB03, American Society of Agricultural and Biological Engineers, St. Joseph, Michigan (USA), 652-670.

Atasever Ş., Erdem H. & Kul E. 2004. Süt Sığırlarında Verim Üzerine Etkili Bazı İklimsel Stres Faktörleri, *4. Ulusal Zootekni Bilim Kongresi* 209-216.

Atrian P. & Shahryar H. A. 2012. Heat Stress In Dairy Cows (a review). *Res. in Zoology*, 2, 31-37.

Bandaranayaka D. D. & Holmes C. W. 1976. Changes in the Composition of Milk and Rumen Contents in Cows Exposed to a High Ambient Temperature with Controlled Feeding. *Trop. Anim. Health Prod.* 8, 38-46.

Balaban A. & Şen E. 1988. Tarımsal Yapılar, *Ankara Ünv. Ziraat Fak. Yayınları*, No: 721, Ankara.

Berman A. 1968. Nychthermeral and Seasonal Patterns of Thermoregulation in Cattle. *Aust. J. Agric. Res.* 19, 181-188.

Berman A., Folman Y. M., Kaim M., Mamen Z., Herz D., Wolfenson A. & Graber Y. 1985. Upper Critical Temperatures and Forced Ventilation Effects for High-Yielding Dairy Cows in a Tropical Climate. *J. Dairy Sci.* 68, 488-495.

Bianca W. 1962. Relative Importance of Dry-and Wet-Bulb Temperatures in Causing Heat Stress in Cattle. *Nature*, 195, 251–252.

Blackshaw J. K. & Blackshaw A. W. 1994. Heat Stress in Cattle and the Effect of Shade on Production and Behaviour. *Aust. J. Exper. Agric.* 34, 285–295.

Blazquez N. B., Long S. E., Mayhew T. M., Perry G. C., Prescott N. J. & Wathes, C. M. 1994. Rate of Discharge and Morphology of Sweat Glands in the Perineal, Lumbodorsal and Scrotal Skin of Cattle. *Res. Vet. Sci.* 57, 277-284.

Brouček J. 1997. Effect of High Temperatures on Cattle. *Agriculture, 43*, 522–542.

Brody S. 1955. Climatic Physiology of Cattle. *Missouri Agric. Exp. Stn. J., Series* 1607.

Collier R. J., Eley R. M., Sharma A. K., Pereira R. M. & Buffington D. E. 1981. Shade Management in Subtropical Environment for Milk Yield and Composition in Holstein and Jersey Cows. *J. Dairy Sci*. 64, 844-849.

Cook N. B., Mentink R. L., Bennett T. B. & Burgi K. 2007. The Effect of Heat Stress and Lameness on Time Budgets of Lactating Dairy Cows. *J. Dairy Sci*. 90, 1674-1682.

Demir Y. 1992. Kapalı Ahırlarda İç Ortam Sıcaklık ve Nemin Dış Ortam Sıcaklık Neminden Etkileniminin Belirlenmesi Üzerine Bir Araştırma. *IV.Ulusal Tarımsal Yapılar Ve Sulama Kongresi*. Erzurum**:** 376-384.

Doležal O., Knížková I., Kudrna V., Dolejš J., Kunc P., Gregoriadesová J. & Černá D. 2004. Thermal Stress in Dairy Cattle – Tactics and Strategy (in Czech). VÚŽV Uhříněves, Praha, pp.56

Ekmekyapar T. & Okuroğlu M. 1984. Yumurta Tavuğu Kümeslerinde Uygun Çevre Koşulları. *Teknik Tavukculuk Dergisi,* 45, 3-14.

Ekmekyapar T. 1991. Hayvan Barınaklarında Çevre Koşullarının Düzenlenmesi. *Atatürk Üniversitesi Ziraat Fakültesi Yayınları* No:306, Erzurum.

FAO. 2016. Animal Environmental Requirements. http://www.fao.org (accessed 26 December 2016)

Frazzi E., Calamari F., Calegari F. & Stefanini L. 2000. Behavior of Dairy Cows in Response to Different Barn Cooling Systems. *Transactions of the ASAE, American Society of Agricultural Engineers* 0001-2351/ 00 / 4302-387, 43(2), 387-394.

Gantner V., Mijić P., Kuterovac K., Solić D. & Gantner R. 2011. Temperature-Humidity Index Values and Their Significance on the Daily Production of Dairy Cattle. *Mljekarstvo*, 61(1), 56-63.

Gaughan J. B., Mader T. L., Holt S. M. & Lisle, A. 2008. A New Heat Load Index for Feedlot Cattle. *J. Anim. Sci.*, 86, 226-234.

Igono M. O., Bjotvedt G. & Sanfordcrane H. T. 1992. Environmental Profile and Critical temperature effects on milk-production of Holstein cows in desert climate. *Int. J. Biometeorology*. 36(2), 77-87.

Johnson H. D., Ragsdale A. C., Berry I.L. & Shanklin M. D. 1963. Temperature-Humidity Effects Including Influence of Acclimation in Feed and Water Consumption of Holstein Cattle. *Misso-uri Agr. Exp. Sta. Res. Bul*. 846.

Johnson H. D. 1987. Bioclimate Effects on Growth, Reproduction and Milk Production. In: Johnson Harold D. (ed.), Bioclimatology and the Adaptation of Livestock. World Animal Science, B5, Chapter 3, Elsevier Science Publishers B.V., Amsterdam, The Netherlands, pp. 35–57.

Kadzere C.T., Murphy M.R., Silanikove N. & Maltz E. 2002. Heat Stress in Lactating Dairy Cows: A Review. *Livestock Production Science* 77, 59-91.

Keown F. J. & Grant R. G. 1997. How to Reduce Heat Stres in Dairy Cattle. http://www. unl.edu/IANR/PUBS/extnpubs/dairy/1063 html.

Legrand A., Schütz K. E. & Tucker C. B. 2011. Using Water to Cool Cattle: Behavioral and Physi-ological changes associated with voluntary use of cow showers. *J. Dairy Sci.*, 94(7), 3376–3386.

Mader T. L., Davis M. S. & Brown-Brandl T. 2006. Environmental Factors Influencing Heat Stress in Feedlot Cattle. *J. Anim. Sci*., 84, 712–719.

Maton A., Daelemans J. & Lambrecht J. 1985. Housing of Animals, *Elsevier Science Publishers B.V.,* Netherlands.

Mutaf S. & Sönmez R. 1984. Hayvan Barınaklarında İklimsel Çevre ve Denetimi, *Ege Üniv. Ziraat Fak. Yayınları* No: 438, E., Ü., Zir. Fak. Ofset Basımevi, Bornova-İzmir.

NRC (National Research Council). 1989. In: Revised Edition Update. Nutrient Requirements of Dairy Cattle. *National Academy Press,* Washington, DC.

Noton, H.N., 1982. Farm Building. By the College of Estate Management White Knights, Reading *RGGZAW*, London.

NRC (National Research Council). 1971. A Guide to Environmental Research on Animals. *Natl. Acad. Sci.,* Washington, DC.

NRC (National Research Council). 1981. Effect of environment on nutrient requirements of domestic animals. BARR Comm. On Animal Nutrition, Board on Agriculture, National Research Council. *National Academy Press,* Washington, DC.

NRC (National Research Council). 1989. In: Revised Edition Update. Nutrient Requirements of Dairy Cattle. *National Academy Press*, Washington, DC.

Okuroğlu M. & Yağanoğlu A. V. 1993. Kültürteknik, *Atatürk Üniversitesi Ziraat Fakültesi Ders Yayınları,* No: 157, Erzurum.

Omar E. A., Kirrella A. K., Soheir A., Fawzy A. & El-Keraby F. 1996. Effect of Water Spray Followed by Forced Ventilation on Some Physiological Status and Milk Production of Post Calving Friesian Cows. Alex. *J. Agric. Res.* 4, 71-81.

Radostits O. M. & Blood D.C. 1985. Herd Health W.B. Saunders, Phikadelphia pp. 176-182.

Ravagnolo O. & Misztal I. 2002. Effect of Heat Stress on Nonreturn rate in Holsteins: Fixed-Model Analyses. *J. Dairy Sci.* 85(11), 3101-3106.

Rhoads M. L., Rhoads R. P. VanBaale J. J., Collier R. J., Sanders S.R., Weber W. J., Spiers B. A., Spain D. E. J. N., Sampson J. D. & Rhoads R. P. 2004. Use of Physiological Parameters to Predict Milk Yield and Feed Intake in Heat-Stressed Dairy Cows" *J. Therm. Biol*. 29, 759-764.

Rhoads M. L., Rhoads R. P., VanBaale, M. J., Collier R. J., Sanders S. R., Weber W. J., Crooker B. A. & Baumgard L. H. 2009. Effects of Heat Stress and Plane of Nutrition on Lactating Holstein Cows: I. Production, Metabolism, and Aspects of Circulating Somatropin. *J. Dairy Sci.* 92, 1986-1997.

Roenfeldt S. 1998. You can't Afford to Ignore Heat Stres. *Dairy Manage.* 35(5), 6-12.

Sainsbury D. W. B. 1974. Health Problems in Intensive Animal Production. In "Environmental Aspects of Housing for Animal Production", J.A. Clark (ed.), Butterworths, London.

Sainsbury D. & Sainsbury P. 1988. General Environmental Effects. In "Livestock Health and Housing", D. Sainsbury and P. Sainsbury (ed.), ELBS, Bailliere Tindall, London.

Schneider P. L., Beede D. K. & Wilcox C. J. 1988. Nycterohemeral Patterns of Acid-Base Status, Mineral Concentrations and Digestive Function of Lactating Cows in Natural or Chamber Heat Stres Environments. *J. Anim. Sci*. 66(1), 112-125.

Schütz K. E., Rogers A. R., Poulouin Y. A., Cox N. R. & Tucker C. B. 2010. The amount of Shade Influences the Behavior and Physiology of Dairy Cattle. *Journal of Dairy Science* 93, 125-133.

Shinde S. & Taneja V. K. 1986. Effect of Physical Environment Dairy Milk Yield in Crossbreds, *Amin. Breed. Abst.* 54(12), 7668.

Shultz T. A. 1984. Weather and Shade Effects on Cow Corral Activities. *J. Dairy Sci.* 67(4), 868-873.

Smith J. F. Collier R. J. Harner J. P. & Bradford B. J. 2012. Strategies to Reduce Heat Stress in Dairy Cattle. *27th Annual Southwest Nutrition and Management Conference Book,* 65-84.

Thatchet W. W. 1974. Effects of Season, Climate and Temperature on Reproduction and Lactation. *J. Dairy Sci*. 57, 360-368.

Titto C. G., Titto E. A. L., Titto R. M. & Mourao G. B. 2011. Heat Tolerance and the Effects of Shade on the Behavior of Simmental Bulls on Pasture. *Animal Science Journal*, 82, 591-600.

Tucker C. B., Rogers A. R. & Shutz K. E. 2007. Effect of Solar Radiation on Dairy Cattle Behaviour, Use of Shade and Body Temperature in a Pasture-Based System. *Appl. Anim. Behav. Sci.* 109, 141-154.

Uğurlu N. & Uzal, S. 2004. Süt Sığırı Barınaklarının Tasarımında Mevsimsel Etkiler. *Selçuk Üniversitesi Ziraat Fakültesi Dergisi*, 18(33), 73-79.

Uzal S. & Uğurlu N. 2008. The Effect of Climatic Condition on Area Preference of Animals in Dairy Cattle Houses. *J. Int. Environmental Application & Science*, 4, 224-233.

Uzal S. & Uğurlu N. 2009. The Effects of Seasons on the Area Usage of Animals in Freestall Dairy Cattle Barn. *International Coference Lake and Nutrient Loads Alblakes* 09, April 24-25, pp. 240-245.

Wathes C. H. Webster A. J. F.& Charles D. R. 1983. Ventilation, Air Hygiene and Animal Healty, Farm Housing, The Veterinary Record 113, 554-559.

Webster A. J. F. 1981. Optimal Housing Criteria for Ruminants. In "Environmental Aspects of Housing for Animal Production", J.A. Clark (ed.), Butterworths, London.

Webster A. J. F. 1994. Comfort and Injury. In "Livestock Housing", C.M. Wathes and D.R. Charles (ed.), *University Press*, Cambridge, pp. 49-67.

West J. W. 2003. Effects of Heat-Stress on Production in Dairy Cattle. *J. Dairy Sci*., 86, 2131-2144.

Williams C. M. 1959. Influence of Winter Conditions on the Feed and Water Intake of f Feedlot Steers. *J. Anim. Sci*. 18, 1155.

WMO. 1989. Animal Health and Production at Extremes of Weather (Reports of the CAgM Working Groups on Weather and Animal Disease and Weather and Animal Health). Technical Note No. 191 (WMO-NO. 685), Genova.

Yeck R. G. & Stewart R. E. 1959. A Ten-Year Summary of the Psychoenergetic Laboratory Dairy Cattle Research at the University of Missouri. *Trans.* ASAE 2, 71–77.

Young B. 1981. Cold Stress as it Affects Animal Production. *Journal of Animal Science*, 52 (1), 154-163.

Yousef M. K. 1985. Stress Physiology: Definition and Terminology (Basic Principles), In: Stress Physiology in Livestock Vol. 1. CRC Press, Boca Raton, FL, Eds, p.

Yüksel A. N. 1993. Kültürteknik, *Trakya Üniversitesi Tekirdağ Ziraat Fak. Yayın* No: 182. Ders Kitabı No: 19, Tekirdağ.

Zimbelman R. B., Rhoads R. P., Rhoads M. L., Duff G. C., Baumgard L. H. & Collier R. J. 2009. A Re-evaluatio of the Impact of Temperature Hu-midity index (THI) and Black Globe Temperature Humidity Index (BGHI) on Milk Production in High Producing Dairy Cows. *Proc. 24th Southwest Nutrition and Management Conference, Tempe,* AZ, 158-168.

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# The Evaluation of Active Green Sites For Recreation: Bor Case

**Gülden SANDAL ERZURUMLU[1*], Nuriye Ebru YILDIZ[2], Barış KAHVECİ[3]**

[1]Niğde University, Faculty of Architecture, Department of Landscape Architecture, Niğde/Turkey
[2]Ankara University, Graduate School of Natural And Applied Sciences, Department of Landscape Architecture, Ankara/Turkey
[3]Çukurova University, Graduate School of Natural And Applied Sciences, Department of Landscape Architecture, Adana/Turkey
[*]Corresponding Author: gpeyzaj@gmail.com

## Abstract

Bor is a central district located in the southeast part of the Central Anatolia Region, within the boundaries of Nigde and surrounded by Aladaglar in the east and Hasan and Melendiz mountains in the north. After the population increased in Bor with the passing of the Ankara-Kayseri and Adana-Konya railways in 1932, the need for green spaces increased due to the effect of construction. In the process, providing livable spaces to communities has become an important issue in environments that are shaped by the combination of natural and cultural objects. In this declaration, the amounts of green areas in the Bor district will be determined; the distribution of the active green areas in the neighborhood scale, the size and the per capita rates will be evaluated within the scope of the "Regulation on the Construction of Spatial Plans" dated 14.06.2014 and numbered 29030 Official Newspaper; recreational usage of available green areas will be discussed and alternative green areas will be proposed which provide effective use to the people of the region.

**Keywords:** Active green sites, Bor, recreation

## INTRODUCTION

Societies have brought together natural and cultural values, while shaping environments they live in; and designed spaces outside the settlement, commerce and industry areas as green spaces throughout history. However, the result of changes in cities, rapid population growth, and intensive construction, the natural areas are being destroyed; environmental problems come to the agenda; the quality of urban life is decreasing, and the need for green spaces is increasing. The quality of urban life affects the physical and mental health of individuals as well as the ecological, economic and social situation of the city in cities shaping up with physical and natural environment integration. In this context, the concept of urban open-green space is on the agenda with the aim of improvement of urban living conditions, and balancing the interaction between individuals and nature.

In the Planned Area Type Construction Regulation numbered 28759, the concept of green space is defined as all of children's playgrounds reserved for community use, recreation, excursion, picnic, and coastal areas. According to this definition, large scale exhibitions, botanical and zoo gardens and regional parks can be evaluated within the scope of the green area. The standards of open-green space are a changeable phenomenon among cities in the country as well as countries in the country.

Because the age, culture, occupation and economic situation of urban people are different, the requirements for green space also vary. In determining the open-green area

norms, social, cultural, economic factors, and usage density as well as the physical environmental characteristics such as climate, topography, urban location of cities play an important role. The open-green areas depend on not only being adequate in terms of quality and quantity to perform their functions in the city but also being the easily accessible to the areas where the societies live in (Gül ve Küçük, 2001).

Regarding the green areas that have an important place in human life, according to 28th article dated 11.7.1972 and amended by the law numbered 14251 of the consruction law numbered 6785, the amount of green space per population based on planning is at least 7 $m^2$ (Önder ve Polat, 2012). In the regulation on plan construction dated 02.11.1985 and numbered 18916 published in the official newspaper, parks, children's gardens and playgrounds are defined as active green area, and total area per capita in urban areas for these three uses is determined as 10 $m^2$ (Bolatoğlu ve Özkan, 2013); the total green area outside the municipality and contiguous area boundaries per person is determined to be at least 14 $m^2$ (Önder ve Polat, 2012).

Finally, "The Regulation on the Construction of Spatial Plans" published in the Official Newspaper dated 14.06.2014 and numbered 29030 and “the Regulation on the Principles of Plan Construction” published in the Official Newspaper dated 2.11.1985 and numbered 18916 were abolished. Social infrastructure areas are defined as “supplying the cultural, social and recreational needs of the individual and the community, and open/closed sports facilities and outdoor and green areas such as parks, children's horticulture, playgrounds, squares, recreation areas, etc. which are made by the public or private sector for the purpose of increasing the quality of life with a healthy environment, health, religious, cultural and administrative facilities” in Article 5, titled "Definitions and Principles of Spatial Use of the Regulation", and in Annex 2, the amount per capita of social and open green areas under the heading of urban, social and technical infrastructure is approved as $10m^2$.

In this decleration, the Bor district of Niğde where the need for green spaces increased due to the effect of construction with the passing of the Ankara-Kayseri and Adana-Konya railways in 1932 was selected as the study area. The study is specific because there is no previous work on Bor's active green areas. In this context, the amounts of green areas in the Bor district will be determined; the distribution of the active green areas in the neighborhood scale, the size and the per capita rates will be evaluated; recreational usage of available green areas will be discussed and alternative green areas will be proposed which provide effective use to the people of the region.

## MATERIAL and METHOD

The main material of the study is Bor district located in the southeast part of the Central Anatolian Region within the Niğde borders, on the Bor Lake between 37 ° 53 'north latitude and 34 ° 33' east longitude; surrounded by Aladağ Mountains in the east the mountains of Hasan and Melendiz Mountains in the north (Figure 1). In order to determine the amounts of active green areas of Bor and evaluate the distributions, sizes and per capita distributions of active green areas in the neighborhood scale, national and international approaches have been examined and visual data has been provided within the scope of field-study studies in the study area and benefited from the 1/1000 scale conservation zoning plan obtained from Bor Municipality and Google Earth 2016 satellite image. In the direction of the provided data, recreational use possibilities of existing green areas were evaluated and suggestions were made about alternative green areas that provide effective use to the people of the region.

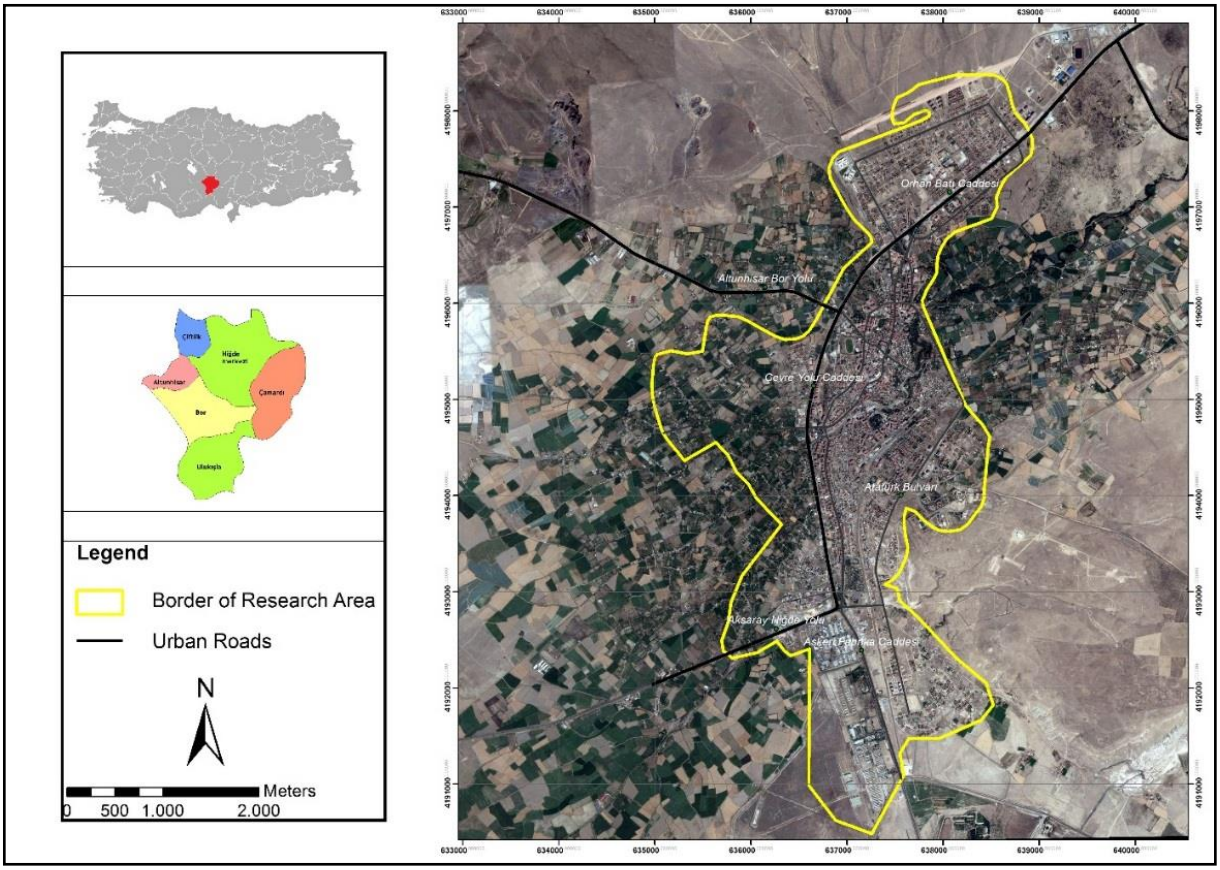


**Figure 1.** Niğde/Bor, geographic location

## RESULTS and DISCUSSION

Bor which has developed rapidly with the reason of migration from villages and different cities, is a district with a population of 36,499 according to the data of 2015 Turkish Statistical Institute. In the study area with approximately 1,300 ha area; Active green areas including children's play areas, neighborhood parks, school gardens, picnic and recreational areas were evaluated together with neighborhood boundaries on the satellite image as shown in Figure 2.

Among the parks located in the research area, only Atıf Gürkan, Üstün and Kayabaşı Park were named; other active green areas are not named, so they are expressed using the names of the neighborhoods where the parks are located. As shown in Table 1, there are greean areas in the 17 neighborhood which is selected as the study area in the boundaries of the Bor district; 12 of them are considered as active green areas. Parks, children's playgrounds, school gardens, recreation and picnic areas at different scales in the active green areas of the district serve public use.

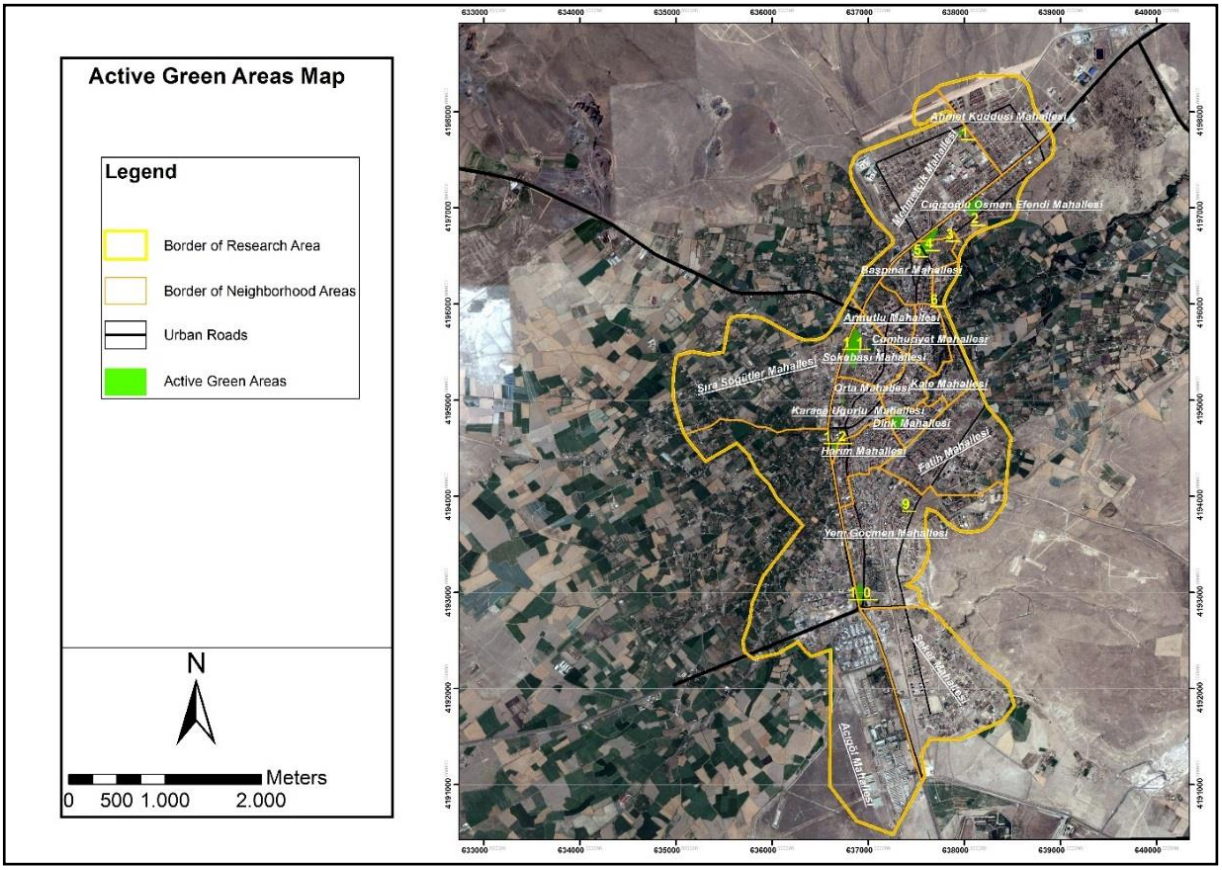


**Figure 2.** Research area active green areas

**Table 1.** The names and populations of the neighborhoods in Bor (TUİK, 2015)

| The Neighborhoods in Bor | Population | The Neighborhoods in Bor | Population |
|---|---|---|---|
| Acıgöl neighborhood | 1.390 | Kale Neighborhood | 817 |
| Ahmet Kuddusi neighborhood | 2.675 | Karaca Uğurlu Neighborhood | 2.631 |
| Armutlu Neighborhood | 2.049 | Mehmetçik Neighborhood | 2.870 |
| Başpınar Neighborhood | 2.055 | Orta Neighborhood | 1.141 |
| Cığızoğlu Osman Efendi Neighborhood | 1.141 | Şeker Neighborhood | 1.460 |
| Cumhuriyet Neighborhood | 1.681 | Sıra Söğütler Neighborhood | 1.317 |
| Dink Neighborhood | 1.161 | Sokubaşı Neighborhood | 1.722 |
| Fatih Neighborhood | 3.994 | Yenigöçmen Neighborhood | 3.903 |
| Harım Neighborhood | 4.492 | **Toplam** | **36.499** |

The World Health Organization states that the green area per capita in the city should be at least 9 $m^2$, and 10-15 $m^2$ is the ideal. In the developed countries, the average green area per capita is 20 $m^2$; it varies from about 1 to 9 $m^2$ in Turkey. In research areas, the amount of green space per capita determined by the proportion of the neighborhoods to the neighborhood population, and the proportion of total green areas to Population of research area is not enough.

However, the amount of green space per capita is above the limit value (10 $m^2$) specified in the regulation due to the low population of some of the neighborhoods or the

possession of urban parks. When the total green area and total population of the research area are evaluated, it is determined that this amount is about 3 $m^2$ below the regulation limit value (Table 2).

**Table 2.** The amount of active green areas in Bor

| Active Green Areas Number | Active Green Areas Name or Kind | Neighborhood | Area ($m^2$) |
|---|---|---|---|
| 1 | | Mehmetçik | 2.881,25 |
| 2 | High School Garden | Cığızoğlu Osman Efendi | 19.527,47 |
| 3 | | Cığızoğlu Osman Efendi | 2.091,60 |
| 4 | | Başpınar | 21.184,11 |
| 5 | Atıf Günkan Park | Başpınar | 6.816,50 |
| 6 | | Kale | 829,94 |
| 7 | | Karaca Uğurlu | 1.290,17 |
| 8 | Üstün Park | Dink | 16.479,06 |
| 9 | | Yeni Göçmen | 4.478,62 |
| 10 | | Yeni Göçmen | 9.933,90 |
| 11 | Kayabaşı Park | Sokubaşı | 36.156,75 |
| 12 | | Karaca Uğurlu | 2.818,94 |
| **Total** | | | **124.488,31** |

In Bor, the numbers determined by the ratio of the number of persons to the green area in the selected areas are low; the amount of green space per capita is not sufficient. When the calculations related to the neighborhoods are examined, it is seen that the amount of green area per person is mostly in Karaca Uğurlu Neignborhood (2,03 $m^2$) and at least in Sokubaşı Neighborhood (0.047 $m^2$).


**Figure 3.** Green Areas from research area

**Table 3.** Total area of active green areas in the research area, amount of green area per person

| Actve Green Areas In The Research Area | | | | |
|---|---|---|---|---|
| **Number** | **Name and Type** | **Area ($m^2$)** | **Neighborhood and Population** | **The amount per capita ($m^2$)** |
| 1 | Playground | 2.881,25 | Mehmetçik (2.870) | 1,00 |
| 2 | High School Garden | 19.527,47 | Cığızoğlu Osman Efendi (1.141) | 18,94 |
| 3 | Playground | 2.091,60 | | |
| 4 | Playground | 21.184,11 | Başpınar (2.055) | 13,06 |
| 5 | Atıf Günkan Park | 6.816,50 | | |
| 6 | Playground | 829,94 | Kale (817) | 1,01 |
| 7 | Playground | 1.290,17 | Orta (1.141) | 1,13 |
| 8 | Üstün Park | 16.479,06 | Dink (1.161) | 14,19 |
| 9 | Playground | 4.478,62 | Yeni Göçmen (3.903) | 3,69 |
| 10 | Playground | 9.933,90 | | |
| 11 | Kayabaşı Park | 36.156,75 | Sokubaşı (1.722) | 20,10 |
| 12 | Playground | 2.818,94 | Karaca Uğurlu (2.631) | 1,07 |
| **Toplam** | | **124.488,31** | Araştırma Alanı Toplamı (36.499) | **3,41** |

When the table 3 is evaluated, it is seen that the amount of green area per person is mostly located in Sokubaşı district (20,10 $m^2$) and at least in Mehmetçik district (1,00 $m^2$). 5 (Mehmetçik, Kale, Karaca Uğurlu, Dink, Yeni Göçmen Parks) of the 12 parks in Bor have children playgrounds. Cığızoğlu Osman Efendi high school in the area has a green area, there is no children's playground (Figure 3). It is seen that there are children's playgrounds in the entire neighborhoods where the active green areas are located. However, these areas were mostly restricted to swings and slides; It has been determined that there is no game equipment that will contribute to the physical development of the children and it is determined that the use of the plant to contribute ecologically and aesthetically to the town is insufficient. The sports and picnic areas are located only in Üstün Park and Kayabaşı Park, which form active green areas outside the children's play area.

It is seen that the green areas which are located in Bor and expressed by the covered areas are not homogeneous and inadequate in the whole district. It is very important to consider of the ecological functions of the green areas as well as the economic functions, and base on the ecological basis of future design approaches in order to understand the interaction between the district population and the active green areas. In order to determine the amount of green space per capita, it is necessary to calculate the ratio of the user population to the amount of green space. In addition to this, it is necessary to determine the adequacy of the amount of green areas per capita throughout the district, to use the green area in accordance with the population and to distribute the green areas homogeneously within the settlement areas.

## CONCLUSIONS

It is known that the urban green areas must be within 5 minutes of walking distance from the residential centers, neighborhoods and shopping centers or be within convenient reach by bicycle. Accessibility of green spaces is an important issue that must be taken into account during the planning and design phase. Developed countries developed proposals in the field of accessibility of green areas. When the UK sample is examined; it is emphasized that At least 1 ha for the area with a population of 1000 in the distance of 300 m from the area between the green area and the residential buildings; at least 20 ha for 2 km distance; at least 100 ha for 5 km distance from the dwelling, and at least 500 ha natural reserve areas for 10 km distance from the dwelling should be formed (Moughtin, C., Shirley, P., 2005).

The social and environmental impact of urban green spaces in quality urban life is important. Advantages of the area are related to accessibility and proximity. It is proved in previous studies that people living in urban areas want to live residence closer to green areas. Burgess, et al. (1988); Coles ve Bussey (2000) ve Grahn and Stigsdotter (2003) are reported that green areas closer to residential areas will be visited more by users. In addition to this, access to parks is an important issue in terms of social interaction (Önder, et al., 2011).

According to the data obtained in the accessibility and spatial analysis within the scope of the research, the following results were obtained:

- It has been observed that there is an insufficient and unbalanced distribution of the green areas in Bor and surrounding areas.
- It has been determined that the playgrounds, sports areas, neighborhoods and district parks, which are considered as green areas in Bor, have a very small area within the given criteria.
- It has been determined that the existing green spaces in Bor do not qualify for the social, cultural and psychological needs of the individuals
- The amount of green space per person in Bor province is inadequate compared to European Union cities; and these areas are well below the criteria when they are examined in the frame of construction law in Turkey.
- Societies that perceive that the green space surrounding them is of better quality perform more physical activity than those who perceive the surrounding green space as less quality (Annear, et al. 2009, Stronegger, et al. 2010, De Jong, et al. 2012).

The importance of green spaces is better understood by ocieties living in urbanization, dense populations, and insufficient green space, and there is no more active green space in urban environments.Considering the ecological functions of urban green areas; the protection of existing green areas on a regional or national scale, and the conception of new green spaces in these circles have an important place in the landscape design. In this context, it is necessary to raise the awareness of local governments and local people, increase the employment of landscape architects by municipalities, and to base the ecological basis of urban landscape designs on the contribution of active green areas to urban life quality and urban ecology.

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## REFERENCES

Annear M.J., Cushman G., Gidlow B. (2009) Leisure time physical activity differences among older adults from diverse socioeconomic neighborhoods. Health and Place 15: 482-490.

Bolatoğlu H. ve Özkan, M. 2013. Torbalı (İzmir) Kenti Yeşil Alan Sistemindeki Kamusal Aktif Yeşil Alanların Yeterliliği ve Geliştirilebilme Olanakları Üzerine Bir Araştırma. Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi 2013; 10(2): 15–23.

Burgess J., Harrison C.M., Limb M. (1988). People, parks and the urban green: a study of popular meanings and values for open spaces in the city. Urban Stud. 25: 455–473

Coles R.W., Bussey S.C. (2000). Urban forest landscapes in the UK – progressing the social agenda. Landscape and Urban Planning 52: 181–188.

De Jong K., Albin M., Skarback E., Grahn P., Bjork J. (2012) Perceived green qualities were associated with neighborhood satisfaction, physical activity, and general health: Results from a cross-sectional study in suburban and rural Scania, southern Sweden. Health & Place 18: 1374-1380.

Grahn P. & Stigsdotter U.A. (2003). Landscape planning and stress. Urban Forestry and Urban Greening 2: 1–18.

Gül A. & Küçük V. 2001. Kentsel Açık-Yeşil Alanlar ve Isparta Kenti Örneğinde İrdelenmesi. Süleyman Demirel Üniversitesi Orman Fakültesi Dergisi, Seri: A, Sayı: 2, Sayfa: 27-48.

Moughtin, C., Shirley, P., 2005. UrbanDesign: Green Dimension, Published by Elsevıer

Önder, S., Polat, A.T., Korucu. S., 2011. The evaluation of existing and proposed active gren spaces in Konya Selçuklu District, Turkey. African Journal of Agricultural Research Vol. 6(3), pp. 738-747.

Önder, S. & Polat, A. 2012. Kentsel Açık-Yeşil Alanların Kent Yaşamındaki Yeri ve Önemi. Kentsel Peyzaj Alanlarının Oluşumu ve Bakım Esasları Semineri, 19 Mayıs, Konya.

Stronegger W.J., Titze S., Oja P. (2010) Perceived characteristics of the neighborhood and its association with physical activity behavior and self-rated health. Health & Place 16: 736-743.

TUİK, 2015, Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları, Belediye, Köy ve Mahalle Sonuçları, https://biruni.tuik.gov.tr/medas/?kn=95&locale=tr (accessed February 25.02.2017).

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# Flaming and Burning as Thermal Weed Control Methods: A Review

**Ali BOLAT[1], Ugur SEVILMIS[1], Ali BAYAT[2]**

[1]Eastern Mediterranean Agricultural Research Institute, Adana/Turkey
[2]University of Cukurova, Faculty of Agriculture, Department of Agricultural Machinery and Technologies Engineering, Adana/Turkey
*Corresponding Author: bolat.ali@tarim.gov.tr

## Abstract

An important part of global pesticide consumption consists of herbicides. But, due to increasing pesticide costs, concerns about pesticides' risks on environment, increasing interest to organic farming, increasing resistance of weeds to herbicides, scientists are searching alternatives to herbicides. The most promising alternative methods are thermal weed control methods. The emissions resulted from these alternative methods don't produce any environmental risk if operated appropriately. Common thermal methods subjected to researches are flame, hot water, steam and infrared heater. The concerns and problems regarding these thermal methods consist of high fuel costs, variable effects depending on weed species, fire risks and injuries on cultivated plant tissues. In this paper, we reviewed international literature on flaming and burning thermal weed control methods.

**Keywords**: Burn, burning, flame, flaming,weed + flame; weed + flaming; weed+ burn;weed + burning.

## INTRODUCTION

Weeds in agricultural fields result with crop yield losses by competing for water, light and land with crops. Chemical fight is the most preferred weed control method today due to its easiness to apply and its fast effect. Due to the negativities of pesticides on human and environment, increasing resistance of weeds to pests and increasing demand for organic products, the use of environmentally friendly new technologies in agricultural struggle is required. Herbicide leaching into surface and ground water and its residues in drinking water and food is an important public problem (Rifai *et al*., 2002).

In thermal weed control, weeds are heated in order to kill them or at least reduce their competitive ability. The heat transfer to the plant surface can take place by convection, radiation, condensation or by conduction for a sufficient period of time. For this purpose, different solutions (flame, hot water, steam, heat radiation) had been developed (Vanhala *et al*., 2004). The principle of thermal treatment is to target the plant for short periods, less than 1 second, with intense temperatures at, or greater than, 100$^{o}$C. Thermal weed control destroys plant cellular material, coagulating plant proteins, thus disabling respiration and normal plant functioning (Hewitt *et al*., 1998). All weeds can be controlled when the thermal weed control reaches a sufficient temperature.

**Flaming**

Flaming is the most widespread thermal weed control method in agriculture (Ascard, 1995). Weed control by flaming is based on heating plant tissue rather than burning it (Leroux *et al*., 2001).

Nozzle size, number of nozzles per metre burner width, the fuel (propane etc.), gas phase or liquid phase burner, flame temperature, gas:air ratio, place of gas and air mix, natural or forced air supply are important parameters (Vanhala *et al*., 2004). Flame applications may be conducted in open and protected flame form. Significant heat losses occur in open flame applications and can damage culture plants. To avoid this damage partly, round (pointed) end flame heads are used. Due to the low flame width of such flame heads, the work width is small and a large number of flame heads are required. This increases fuel consumption. To avoid heat losses, reduce damage to the crops and to increase working width of each flame head, flameproof heads (jet type) are used. Flame weeding is often used for weed control in organic production where use of herbicides are prohibited (Sivesind *et al*., 2009). Flaming has been more effective against broadleaf weeds than grasses (Cisneros & Zandstra, 2008). Any research experiment may include comparing the efficacy of different weed control tools or methods, assess the effect of timing, dose or intensity or different combinations of methods (Vanhala *et al*., 2004). Flaming would not be very competitive in areas where herbicides and conventional cultivation give satisfactory control of weeds. Chemicals gave the most effective weed control and the highest yield due to their selectivity and ability to move throughout the weed to control its underground and above-ground parts (Rifai *et al*, 1996). Flaming works best on small annual weed seedlings. Larger and more mature weeds require more intense heat and are difficult to kill with flaming (Holekamp, 1954).

Flaming is a good alternative to herbicide applications on hard urban surfaces and to mechanical means (e.g., string trimmers) which can seriously damage surfaces (Raffaelli *et al*., 2013). A greater knowledge on the development of dose–response curves for determining the appropriate propane dose for effective weed control in major agronomic crops is needed to improve flame-weeding strategies (Datta & Knezevic, 2013). Flame weeding is less costly than hand-weeding (Nemming, 1993). Flame weeding can be used when the soil is too moist for mechanical weeding (Domingues *et al*., 2008). Flame weeding can be used in pre-sowing, pre-emergence or pre-transplanting of culture crops (Peruzzi *et al*., 2007). Post-emergence flame weeding can be used in heat-tolerant crops like maize (Ulloa *et al*., 2011a), soybean (Knezevic *et al*., 2013), sorghum (Ulloa *et al*., 2011b). According to Rahkonen *et al*. (1999), flaming have little effect on microbial biomass deeper in the soil (5–10 mm). The soil temperature at 5 mm depth was raised by 4.0°C and at 10 mm by 1.2°C. The threat that flaming poses to soil microorganisms is small. The use of herbicides in urban areas are strictly regulated. As an alternative to herbicides, thermal equipments can be used successfully for weed control on hard surfaces (Peruzzi *et al*.,2010). Flaming was also used for insect control in dormant alfalfa (Thaddeus, 2001).

**Burning**

Soil burning is a traditional agricultural practice in restricted areas of the Ethiopian highlands (Pülschln & Koch, 1990). The main grazing management practice in the Kansas Flint Hills is burning annually in spring in March or April. This is followed by intensive grazing with beef cattle for a short period from April to August (Alexander *et al*., 2016). Windrow burning is a tool implemented in Western Australia for harvest weed seed management (Walsh & Newman, 2007). Burning can recycle nutrients tied up in old plant tissue, control many woody plants and herbaceous weeds, improve poor quality forage,

increase plant growth, and improve certain wildlife habitat. To minimize smoke impacts and protect public health, burning would be conducted under appropriate atmospheric conditions. (Howenstine *et al*., 2012).

Stubble burning is probably the oldest form of weed seed control, however, there is very little information on the effectiveness of this practice as a means of destroying weeds seeds (Walsh, & Newman, 2007).Articles and their selected core results on flame and burning weed control are listed in Table 1.

**Table 1.** Articles on Flaming/Burning Weed Control (in chronological order)

| No | Article | Method | Application | Main Results |
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| 1 | Holekamp, 1954 | Flaming the drill row in cotton. Two flat burners staggered on opposite sides of the row. | Flame | Excellent control of annual weeds in cotton has been obtained by supplementing regular cultivation with the application of flame to the drill row. |
| 2 | Cannon & Hamilton, 1963 | Flame compared with herbicides | Flaming | Flame cultivation was effective in controlling weed seedlings in the drill row from the first irrigation until layby. The flamer destroyed many of the lower leaves. |
| 3 | Peacock *et al*., 1965 | Chemical, mechanical and flame treatments | Flaming | The flame cultivator gave preemergence weed control. |
| 4 | Jeffery, & Henard, 1970 | Burning wheat stubble before sowing soybeans. | Burning | Soybeans were direct sown into a wheat stubble, burning the stubble before sowing enhanced weed control regardless of herbicide treatment. Burning the wheat stubble provided season-long weed control regardless of row-spacing. |
| 5 | Whitney *et al*., 1970 | Grapefruit trees. Compared flaming, mechanical tree hoeing, and herbicide. | Flaming | Generally, flaming was the most expensive method of weed control while the mechanical tree hoe was the least expensive. |
| 6 | Parish, 1990 | Greenhouse and field trials. Weed seedlings. | Flame | Treatment of seedlings which germinated over a short period was more effective. |
| 7 | Pülschln, & Koch, 1990 | Soil of grazed fallows are burnt and unburned. | Burning | On burnt spots weeds developed just about 1/3 of the cover on unburnt ones with a comparatively low share of monocotyledonous species. |
| 8 | Balsari *et al*., 1993 | Post-emergence of the weeds before transplanting the lettuce. | Flame | Best results were obtained at 0.27 – 0.42 m · s-1 speed, 0.20 MPa pressure, with weeds at first stage of growth. Flame weed control alone at 0.27 m s-1 gave a lettuce yield that did not differ from the one obtained with the chemical application. |
| 9 | Storeheier, 1993 | Open flamers compared to shielded flamers | Flaming | Shields should be long and relatively low roofed in order to keep the combustion gases close to the ground for as long time as possible. |
| 10 | Ascard, 1995 | Field experiment, natural weed flora at different developmental stages. | Flame | Weed species with unprotected growing points and thin leaves were susceptible. When these plants had 0-4 true leaves, complete kill was achieved at propane doses of 20-50 kg ha-1. Species with protected growth points were tolerant due to regrowth after flaming, and they could be completely killed only in the early stages. Increasing leaf numbers resulted with |

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| | | | | increased propane requirement. |
| 11 | Rifai *et al*., 1996 | In onions and carrots. | Flame | Flaming should be a preventive method, weeds should be controlled as soon as they appear in the crop. Flaming weeds without crop damage becomes increasingly difficult as the weeds grow larger. Flaming is not a cure for every crop. Supplement it to herbicides or mechanical cultivation for better weed control. |
| 12 | Ascard, 1998a | Testing flame burner angle in the field. | Flame | No significant differences observed between the effects of the different burner angles. Weed species with protected growing points were tolerant to flames, whereas species with sensitive leaves and exposed growing points were susceptible. |
| 13 | Ascard, 1998b | Comparison of flaming and infrared radiation techniques in Sinapis alba | Flaming, infrared radiation | The flamer showed better performance than the infrared radiator on plants at the four-leaf stage, but the opposite was true on plants at the cotyledon stage. Both thermal weeders required an effective dose of propane of about 60 kg ha−1 to obtain 95% reduction of plants at the zero- to two-leaf stage. At equivalent propane doses, the flamer gave higher temperatures than the infrared radiator at 1 cm above ground, but temperatures were similar at 3·5 cm height. |
| 14 | Hewitt*et al*., 1998 | Conducted on a surrogate oat crop and a weed infested pasture | Flame, hot water | Hot water was equally as effective as glyphosate. Flaming was not as effective, however, acceptable weed kill was obtained on juvenile weeds. Thermal weed control is most effective when two sequential applications occur 3-4 weeks apart. Repeat applications of thermal methods markedly increase the efficacy of weed kill. |
| 15 | Rahkonen *et al*. 1999. | Soil microbial effect. | Flaming | Flaming have little effect on microbial biomass deeper in the soil (5–10 mm). The soil temperature at 5 mm depth was raised by 4.0°C and at 10 mm by 1.2°C. It is concluded that the threat that flaming poses to soil microorganisms is small. |
| 16 | Rifai *et al*., 1999 | Flaming, hot-steam and mulching on the natural weed flora at different developmental stages in apples. | Flaming, hot-steam | The effect of flaming on annual weeds depends mainly on the developmental stage of weed species and the propane dose required for the desired control level. The hot steam technology was not effective. An exposure time of 540 s at 150°C of the steam was not sufficient to control weeds. Mulching was a good alternative to reduce herbicide use. |
| 17 | Brunclík & Lacko-Bartošová, 2001 | Susceptibility of different weed species. | Flaming | At least two flaming treatments at ground speed of 4 $km.h^{-1}$, angle of burners position adjusted at 40° to ground surface, above ground level of burners 0,14 m, gas pressure of 0,2 MPa at the gas propane doses (consumption) of single treatment of 27 $kg.ha^{-1}$ were good resulted. |

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| 18 | Thaddeus, 2001 | Flaming winter annual weeds and/or insect pests compared with herbicide and insecticide treatments | Flaming | Alfalfa yield evaluations revealed the flamed alfalfa treatments had higher yields than the untreated check. |
| 19 | Mojžiš, 2002 | Onion field with wild oats and wild radish | Flame | The change of gas consumption influenced the effectivity of weed control. Control of the wild oats varied from 31% to 93% . Control of wild radish varied from 21% to 93%. |
| 20 | Rasmussen, 2003 | Punch or normal planting with or without flame weeding in fodder beet for five planting dates. | Flame | Punch planting with flame weeding offers a promising method of weed control in organic farming. |
| 21 | Raffaelli *et al*., 2004 | Comparison of hand hoeing with flaming for intra-row weed control in Artichoke | Flaming | Flaming permitted a work saving. Yield was not different. Flaming is efficient for intra-row weed control in artichoke. |
| 22 | Shimi & Faghih, 2004 | Flaming compared to hand weeding and herbicides in onion fields | Flaming | All treatments plus one hand weeding controlled weeds effectively and boosted yields. Flaming can replace herbicides in onion fields. |
| 23 | Fereidonpoor *et al*, 2006 | Field experiment; flame and herbicide | Flame | Treflan+ once hoeing at 8th weeks and the application of flamer twice at the 20cm and 40 cm height of plant were the best result. |
| 24 | Narwal *et al*., 2006 | Effect of tillage practices and stubble burning on seed bank. | Burning | In 2005 wheat straw burning with chisel ploughing and mould board ploughing treatments were similar in reducing the weed biomass. |
| 25 | Bower *et al*., 2006 | Burning grazing plots to reduce Urochloa mutica. Frogs were also monitored. | Burning | Marbled frogs declined correlated with vegetation biomass. Knowledge about impacts of planned weed control is critical. |
| 26 | Ostojić, 2007 | Maize crop, flame temperatures from 110 to 350°C at up to the 8 true leaves stage. | Flame | 110°C flame temperature destroyed all weed seedlings up to the 2 true leaves stage. At the 4-6 true leaves stage 175°C was required for 80% control. Over 85% control at the 8 true leaves stage was only achieved by using 350°C flame temperature. |
| 27 | Walsh & Newman, 2007 | 10% of field area is exposed by burning narrow windrows to kill weed seeds practice | Burning | Preliminary kiln studies determined that temperatures in excess of 400 °C for at least 10 s were needed to guarantee the death of ryegrass seeds while 500 °C for the same duration was required to kill wild radish seed within their pod segments. Burning exposes the soil surface, increasing the potential for erosion. |
| 28 | Cisneros & Zandstra, 2008 | Conducted with a conveyor bench burner apparatus. Applied to broadleaf and grass seedlings at different stages. | Flame | A few plants survived when flamed at 8 km/h. Some seedlings were more tolerant. Some large plants survived flaming at both growth stages. |

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| 29 | Da Silva *et al*, 2008 | Organic field beans | Flaming | Flaming with machine on organic soil beans is feasible, but equipments require a re-engineering work to adequation of crop characteristics. |
| 30 | Domingues *et al*., 2008 | Broadcast flaming on four weed species | Flaming | Unlike the broadleaf species, the growing points of grass species remained undisturbed below the soil surface at the time of flaming. Grass species were more tolerant to propane flaming than broadleaf species. The sensitivity of grass to flaming also varied between the species. |
| 31 | Sivesind *et al*., 2009 | Five common weed species | Flame | Dicot species were more effectively controlled than monocot species. Flame weeding can be an effective and labor-saving weed control method, partially dependent on the weed flora. Knowledge of the local weed flora and their susceptibility to flame weeding is vital for the effective use of this method. |
| 32 | Saglam & Kiran, 2010 | Vineyard | Flame | 82% of narrow leaf weeds and 72.5% of broad leaf weeds were eliminated with flame. |
| 33 | Peruzzi *et al*. 2010 | Flaming treatments on weed density reduction and LPG consumption and cost. | Flaming | The specific nozzles and rod burners used, together with the water heat exchanger, allowed a high efficiency of the machine and a reduced LPG consumption. |
| 34 | Ulloa *et al*., 2010a | Broadcast flaming; propane dose and crop growth stage; field experiment in sweet maize. | Flaming | V7 was the most tolerant while V2 was the least tolerant stage for broadcast flaming. V7 stage can tolerate higher dose of propane for the same yield reduction compared to the other growth stages. Flaming has a potential to be used effectively in organic sweet maize production if properly used. |
| 35 | Ulloa *et al*., 2010b | Six annual weed species' tolerance to broadcast flaming | Flaming | Broadleaf weeds were more susceptible to flaming than the grass regardless of the growth stage. Overall response to flaming varied among species, growth stage and propane dose. |
| 36 | Knezevic *et al*., 2011 | Seven treatments applied at several growth stages of maize. Banded and broadcast flaming | Flaming | The best treatment was a combination of cultivation and banded flaming conducted twice, at the V3 and V6 stages of maize. |
| 37 | Petrović & Đurić, 2011 | Effect of different propane dozes in weed flaming in soybean and corn crop on the number of systemic group of microorganisms in soil. | Flaming | The most sensitive group of microorganisms on weed flaming was the group of bacteria and the most tolerant were fungi in both investigated crops. |
| 38 | Avishek *et al*., 2012 | Propane flaming in combination with cultivation in maize and soybean. banded flaming, broadcast flaming | Flaming | In maize, the combination treatment of mechanical cultivation and banded flaming applied at the V4 and V6 stages provided >90% weed control, which was similar to the weed-free control. In soybean, the highest yields were obtained in the weed-free control and the plots flamed plus cultivated twice at the VC and V4 stages (2.8 t $ha^{-1}$). |

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| 39 | Loghavi & Loni, 2012 | Machine vision and image analysis techniques used in real time application of variable rate flame weeding in maize | Continuous or targeted flaming | In general, continuous and targeted flaming showed similar results in weed eradication, while fuel consumption of the targeted method was significantly lower. Weed eradication was higher at lower travel speeds. Targeted discrete flame weeding by using machine vision technology has a potential for uniform flaming with lower fossil fuel consumption and air pollution. |
| 40 | Ulloa *et al*., 2012 | Greenhouse, maize, soybean, two weed species, propane, doses, hand flamer | Flaming | All plant species were more susceptible to flaming during the afternoon. Leaf relative water content could be one of the factors affecting plant response to flaming. Broadleaf species were more susceptible to flaming than grasses. |
| 41 | Raffaelli *et al*., 2013 | LPG fed flaming machines used in urban and sub-urban in comparison with herbicides or mowing. | Flame | Flaming can be both less expensive and more effective than the ordinary treatments in urban areas. Flaming was more effective than mowing in the suburban area but much more expensive, thus an integrated approach would be advisable. |
| 42 | Knezevic *et al*., 2014 | Testing tolerance of selected early-season weeds to broadcast flaming in no-till systems. | Flaming | Response to broadcast flaming varied among species and growth stages. Single application of broadcast flaming can be an effective tool for controlling a few weed species. |
| 43 | Loni *et al*., 2014 | Targeted-discrete flame weeding by using machine vision technology; laboratory and field tests | Flame | Optimum position of burners were 25 cm above the ground surface and inclined at 30º for achieving acceptable accuracy in laboratory application of targeted flaming. First flaming was significantly more effective than the second and third flaming. |
| 44 | White & Boyd, 2016 | Blueberry fields. | Dry heat, direct flame, straw burning | Germination decreased more rapidly at higher temperatures in all species. Duration of heat exposure required to reduce germination by 50 and 90% varied across temperatures and species. Exposure of seeds to direct flame rapidly reduced germination. Less than 1 s of exposure required to reduce seed germination of 3 varieties by > 90%. Thermal technologies that expose weed seeds to direct flame will be the most consistent in reducing seed viability. |
| 45 | Stepanovic *et al*., 2016 | Field experiments with organic soybean; flaming and cultivation with and without manure | Banded & broadcast flaming | The combination of mechanical cultivation and banded flaming applied twice (at VC and V4–V5) was the best treatment resulting in 80–82% weed control and 6–9% crop injury. Soybean recovered well after all flaming treatments, with the exception of broadcast flaming conducted twice. Combining flaming with cultivation effectively control weeds in organic soybean production. |
| 46 | Stepanovic *et al*., 2016 | Flaming and cultivation with and | Banded & broadcast | No interaction between manure application and weed management treatments. Maize |

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| | | without manure in organic maize | flaming | showed good tolerance to all flaming treatments. Best weed control was achieved with banded flaming. Flaming and cultivation applied separately or combined in a single operation, as a single trip across the field, have a potential to be used for weed control in organic maize production systems. |
| 47 | Martelloni *et al*., 2016 | Maize, LPG, cross flaming | Flaming | Overall response of maize yield to flame weeding was influenced by LPG dose, number of flame weedings, maize growth stage, and presence of weeds. Two cross-flaming treatments applied separately with an LPG dose ranging from 36 to 42 kg $ha^{-1}$ can provide an acceptable level of weed control in maize for economically acceptable yields. |
| 48 | Martelloni *et al*., 2016 | Cross-flaming, LPG on dry beans | Flaming | Bean flamed at BBCH 13 stage had little tolerance to cross-flaming. Bean flamed at BBCH 14 stage was tolerant until an LPG dose of 39 kg/ha. |

## RESULTS and DISCUSSION

To see the effects of flaming on ecology in scientific literature, "burning" and "weed" combined keywords produce very much info related to these kinds of applications. This keyword combination also gives too many patents.

In noxious-weed covered irregular sloped pastures, which covers huge areas in the world, flaming may be a good way to destroy weeds without increasing erosion sourced from plowing or without environment contamination sourced from herbicides. Image analysis techniques may be used used with real time application of variable rate flame weeding technique with man drivers. Targeted flaming will reduce fuel consumption significantly compared to continuous flaming. These types of areas cover huge areas all around the world; one example is East Europe countries including Turkey. An operation covering three years with 4-5 applications will possibly reduce tough perennials successfully, too. A shape recognition system with endemic plants image database may be used to protect selected species to reduce spraying application but will destroy undefinied species. So, using a noxious-weeds image database to select and flame target will be a more environmental method. Declines in vegetation biomass will effect accompanying animals. To reduce this effect and protect these communities, unflammed spots will be needed in this system. Flaming these areas early in the season when weeds are small will be more effective. Flaming is also a very appropirate method to use in urban areas, organic fields, railways and raodways to fight weeds without environmental pollution. Also flaming will reduce the negative effects of burning on vehicle traffic on roads. Flaming reduces workpower requirement significantly compared to plowing and handweeding. Flaming is a promising method to use in ridge cultivation and drip irrgiation techniques due to no disturbance and damage to soil level and pipes. Flaming may be a very economic method in conventional agriculture if targeted-discrete flame weeding by using machine vision technology used. Very few studies exists in insect fighting in between weed fighting, so more researches may be needed on this subject. There exists researches on open and shielded flamers but looks like need researches on appropirate nozzle types.

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**REFERENCES**

Alexander, J. A., Fick, W. H., Lemmon, J., Gurule, C. A., Preedy, G. W., & Olson, K. C. 2016. Effects of Growing-Season Prescribed Burning on Vigor of the Noxious Weed Sericea Lespedeza (Lespedeza cuneata) in the Kansas Flint Hills. Kansas Agricultural Experiment Station Research Reports, 2(1), 14.

Ascard, J. 1995. Effects of flame weeding on weed species at different developmental stages. Weed Research, 35(5), 397-411.

Ascard, J. 1998a. Flame weeding: Effects of burner angle on weed control and temperature patterns. Acta Agriculturae Scandinavica B—Plant Soil Sciences, 48(4), 248-254.

Ascard, J. 1998b. Comparison of flaming and infrared radiation techniques for thermal weed control. Weed Research-Oxford, 38, 69-76.

Avishek, D., Stepanovic, S., Neilson, B., Bruening, C., Gogos, G., & Knezevic, S. 2012.Effect of flaming and cultivation on weed control and yield in maize and soybean. In Proceedings of the First International Conference on Robotics and Associated High-Technologies and Equipment For Agriculture. Applications of Automated Systems and Robotics for Crop Protection İn Sustainable Precision Agriculture,(RHEA-2012) Pisa, Italy-September 19-21, 2012 (pp. 61-66). University of Pisa.

Balsari, P., Berruto, R., & Ferrero, A. 1993. Flame weed control in lettuce crop. In Symposium on Engineering as a Tool to reduce Pesticide Consumption and Operator Hazards in Horticulture 372 (pp. 213-222).

Bower, D. S., Valentine, L. E., Grice, A. C., & Schwarzkopf, L. 2006. Reducing weed biomass by burning and grazing can adversely affect frogs, South Australia.

Brunclík, p., & Lacko-Bartošová, M. 2001. Evaluation of weed species susceptibility to flaming. Acta fytotechnica et zootechnica, 4(5).

Cannon, M. D., & Hamilton, K. C. 1963. Use of Flaming, Berbicides in Cotton Weed Control. Progressive Agriculture in Arizona.

Cisneros, J. J., & Zandstra, B. H. 2008. Flame weeding effects on several weed species. Weed Technology, 22(2), 290-295.

Da Silva, M. R., Lucarelli, J. D. F., & Daniel, L. A. 2008. Flaming use to weed plants control on organic soil beans cultivation: carry out of a case. In Central theme, technology for all: sharing the knowledge for development. Proceedings of the International Conference of Agricultural Engineering, XXXVII Brazilian Congress of Agricultural Engineering, International Livestock Environment Symposium-ILES VIII, Iguassu Falls City, Brazil, 31st August to 4th September, 2008. International Commission of Agricultural Engineering (CIGR), Institut fur Landtechnik.

Datta, A., & Knezevic, S. Z. 2013. Flaming as an alternative weed control method for conventional and organic agronomic crop production systems: a review. Advances in agronomy.

Domingues, A. C., Ulloa, S. M., Datta, A., & Knezevic, S. Z. 2008. Weed response to broadcast flaming. RURALS: Review of Undergraduate Research in Agricultural and Life Sciences, 3(1), 2.

Fereidonpoor, M., Shirvanian, A., Behaeen, M. A., & Hekmat, M. H. 2006. The investigation of flame cultivation for weed control on cotton field and comparison with conventional control methods.

Hewitt, M., Bullen, K., & George, D. 1998. Comparison of three weed control methods: chemical, flame and hot water. In Proceedings of the 9th Australian Agronomy Conference" Agronomy-Growing a Greener Future". Australian Society of Agronomy, Charles Sturt University, Wagga Wagga (pp. 607-608).

Holekamp, E. R. 1954. Weed Control By Flame Cultivation. Progressive Agriculture in Arizona.

Howenstine, J., Beckwith, T., McKinley, A., Schaumann, K., Warmbier, K., Notch, T., & Cisneros, E. 2012. Final Environmental Assessment Prescribed Burning for Weed Management on FE Warren Air Force Base, Wyoming. Booz-Allen And Hamılton Inc Mclean Va.

Jeffery, L., & Henard, T. S. 1970. Effect of row-spacing and stubble burning on weed control in soybeans plasted fe wheat stubble. In Abstract Proceedings 25th North Central Weed Control Conference.

Knezevic, S., Datta, A., Stepanovic, S., Bruening, C., Neilson, B., & Gogos, G. 2011. Weed control with flaming and cultivation in corn. Phytopathology, 101, 81-92.

Knezevic, S. Z., Stepanovic, S., & Datta, A. 2014. Growth stage affects response of selected weed species to flaming. Weed technology, 28(1), 233-242.

Knezevic, S. Z., Stepanovic, S., Datta, A., Nedeljkovic, D., & Tursun, N. 2013. Soybean yield and yield components as influenced by the single and repeated flaming. Crop protection, 50, 1-5.

Leroux, G. D., Douhéret, J., & Lanouette, M. 2001. Flame weeding in corn. In Physical Control Methods in Plant Protection (pp. 47-60). Springer Berlin Heidelberg.

Loghavi, M., & Loni, R. 2012. Comparison of Uniform and Targeted Discrete-Flame Weeding Methods for Inter-row Weed Control in Maize Planting. In 2012 Dallas, Texas, July 29-August 1, 2012 (p. 1). American Society of Agricultural and Biological Engineers.

Loni, R., Loghavi, M., & Jafari, A. 2014. Design, development and evaluation of targeted discrete-flame weeding for inter-row weed control using machine vision. American Journal of Agricultural Science and Technology, 2(1), 17-30.

Martelloni, L., Fontanelli, M., Frasconi, C., Raffaelli, M., & Peruzzi, A. 2016. Cross-flaming application for intra-row weed control in maize. Applied Engineering in Agriculture, 32(5), 569-578.

Mojžiš, M. 2002. Energetic requirements of flame weed control. Research in Agricultural Engineering, 48(3), 94-97.

Narwal, S., Sindel, B. M., & Jessop, R. S. 2006. Tillage and residue burning affects weed populations and seed banks. Communications in agricultural and applied biological sciences, 71(3 Pt A), 715-723.

Nemming, A. 1993. Costs of flame cultivation. In Symposium on Engineering as a Tool to reduce Pesticide Consumption and Operator Hazards in Horticulture 372 (pp. 205-212).

Ostojić, Z. 2007. Weed control with a burning flame. Glasilo Biljne Zaštite, 7(1), 41-43.

Parish, S. 1990. The flame treatment of weed seedlings under controlled conditions. The flame treatment of weed seedlings under controlled conditions., (45), 193-196.

Peacock, J. F., Burnside, O. C., Lavy, T. L., Hanway, D. G., & Kittock, D. L. 1965. Flaming, intertillage, and chemical weed control in castorbeans. Weeds, 290-292.

Peruzzi, A., Ginanni, M., Fontanelli, M., Raffaelli, M., & Barberi, P. 2007. Innovative strategies for on-farm weed management in organic carrot. Renewable Agriculture and Food Systems, 22(4), 246-259.

Peruzzi, A., Lulli, L., Fontanelli, M., Frasconi, C., Ginanni, M., Raffaelli, M., & Sorelli, F. 2010. Innovative Strategies For Physical Weed Control On Hard Surfaces In Urban Area In Central Italy: Development Of New Flamıng Operative Machines.

Petrović, B., & Đurić, S. 2011. Effect of weed flaming on the number of systemic groups of microorganisms in soil. In Smotre naučnih radova studenata poljoprivrede i veterinarske medicine sa međunarodnim učešćem= Conference of Agricultural Students and Veterinary Medicine with International Participation, 35, Novi Sad (Serbia), 18 Nov 2011. Poljoprivredni fakultet.

Pülschln, L., & Koch, W. 1990. The significance of soil burning ("Guie") in Ethiopia with special regard to its effects on the agrestal weed flora. Journal of Agronomy and Crop Science, 164(4), 254-261.

Raffaelli, M., Filippi, F., Peruzzi, A., & Graifenberg, A. 2004. Flaming for intra-row weed control in Globe Artichoke. In Proceedings of 6 th EWRS Workshop on Physical and Cultural Weed Control.

Raffaelli, M., Martelloni, L., Frasconi, C., Fontanelli, M., & Peruzzi, A. 2013. Development of machines for flaming weed control on hard surfaces. Applied engineering in agriculture, 29(5), 663-673.

Rahkonen, J., Pietikäinen, J., & Jokela, H. 1999. The effects of flame weeding on soil microbial biomass. Biological agriculture & horticulture, 16(4), 363-368.

Rasmussen, J. 2003. Punch planting, flame weeding and stale seedbed for weed control in row crops. Weed Research, 43(6), 393-403.

Rifai, M. N., Astatkie, T., Lacko-Bartosova, M., & Gadus, J. 2002. Effect of two different thermal units and three types of mulch on weeds in apple orchards. Journal of Environmental Engineering and Science, 1(5), 331-338.

Rifai, M. N., Zikla, T., & Mojzis, M. 1996. Flame and mechanical cultivation for weed control. Zemedelska Technika-UZPI (Czech Republic).

Rifai, N., Lacko-Bartošová, M., & Somr, R. 1999. Weed control by flaming and hot steam in apple orchards. Plant Protection Science, 35(4), 147-152.

Saglam, C., & Kiran, T. 2010. Comparison of Flame Weeding With Other Methods in Vineyard Weed Control. Tarım Makinaları Bilimi Dergisi, 6(3).

Shimi, P., & Faghih, A. 2004. Investigating efficacy of flaming compared to common methods of weed control in seeded onion fields.

Sivesind, E. C., Leblanc, M. L., Cloutier, D. C., Seguin, P., & Stewart, K. A. 2009. Weed response to flame weeding at different developmental stages. Weed technology, 23(3), 438-443.

Stepanovic, S., Datta, A., Neilson, B., Bruening, C., Shapiro, C., Gogos, G., & Knezevic, S. Z. 2016. The effectiveness of flame weeding and cultivation on weed control, yield and yield components of organic soybean as influenced by manure application. Renewable Agriculture and Food Systems, 31(4), 288-299.

Storeheier, K. J. 1993. Basic investigations into flaming for weed control. In Symposium on Engineering as a Tool to reduce Pesticide Consumption and Operator Hazards in Horticulture 372 (pp. 195-204).

Thaddeus, R. 2001. Winter annual weed and early spring insect control using propane flaming in dormant alfalfa.

Ulloa, S. M., Datta, A., Bruening, C., Gogos, G., Arkebauer, T. J., & Knezevic, S. Z. 2012. Weed control and crop tolerance to propane flaming as influenced by the time of day. Crop protection, 31(1), 1-7.

Ulloa, S. M., Datta, A., Bruening, C., Neilson, B., Miller, J., Gogos, G., & Knezevic, S. Z. 2011a. Maize response to broadcast flaming at different growth stages: effects on growth, yield and yield components. European journal of agronomy, 34(1), 10-19.

Ulloa, S. M., Datta, A., & Knezevic, S. Z. 2010b. Tolerance of selected weed species to broadcast flaming at different growth stages. Crop protection, 29(12), 1381-1388.

Ulloa, S. M., Datta, A., & Knezevic, S. Z. 2011b. Growth stage influenced sorghum response to broadcast flaming: Effects on yield and its components. Agronomy journal, 103(1), 7-12.

Ulloa, S. M., Datta, A., Malidza, G., Leskovsek, R., & Knezevic, S. Z. 2010a. Timing and propane dose of broadcast flaming to control weed population influenced yield of sweet maize (Zea mays L. var. rugosa). Field crops research, 118(3), 282-288.

Vanhala, P., Kurstjens, D., Ascard, J., Bertram, A., Cloutier, D. C., Mead, A., ... & Rasmussen, J. 2004. Guidelines for physical weed control research: flame weeding, weed harrowing and intra-row cultivation. In Proceedings 6th EWRS Workshop on Physical and Cultural Weed Control, 194-225 (pp. 194-225).

Walsh, M., & Newman, P. 2007. Burning narrow windrows for weed seed destruction. Field Crops Research, 104(1), 24-30.

White, S. N., & Boyd, N. S. 2016. Effect of dry heat, direct flame, and straw burning on seed germination of weed species found in lowbush blueberry fields. Weed Technology, 30(1), 263-270.

Whitney, J. D., Phillips, R. L., & Tucker, D. P. H. 1970. A Comparison of Herbicide, Mechanical Tree Hoe, and Flaming Treatments in a 2-Year Weed Control Experiment. In Proceedings Florida State Horticultural Society (Vol. 83).

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# The Evaluation of Kayseri, Ağırnas Traditional Houses in the Frame of Ecological Design

**Elmas ERDOĞAN[1*], Nuriye Ebru YILDIZ[2]**

[1]Ankara University, Faculty of Agriculture, Department of Landscape Architecture, Ankara/Turkey
[2]Ankara University, Graduate School of Natural And Applied Sciences, Department of Landscape Architecture, Ankara/Turkey
[*]Corresponding Author: eerdogan@ankara.edu.tr

## Abstract

As the result of intensive urbanization and construction activities, cultural historical environments are facing with the threats such as abondonment and deterrioration. In this context, traditional housing areas are the mostly effected areas in the urban fabric. One of the most important responsibility of the communities is the preservation of natural & cultural values of traditional settlements as well as their memorial & symbolic values. So, planning and design processes must be based on ecological basis, and nature friendly approaches should be adopted to ensure the sustainable urban development as far as spatial and sociocultural factors are concerned. Traditional/vernacular architecture of the region was shaped due to environmental factors and echological data throughout history which carries all the requirements of energy efficent ecological design. The most important reasons why settlements belonging to historical religions reached today is the formation of the buildings by using local material by using environmental sources efficiently. Ağırnas which is a sub settlement of Kayseri that is located on the east of the city centre is dating back to 3000 B.C. Ağırnas which was declared as an urban site that has to be conserved has been a settlement of various civilizations and cultures throught history which is characterized by its traitional stone masonary houses. Societies that have lived in Ağırnas through history have built their monumental buildings and houses using natural stone and timber with appropriate techniques and structural systems. In this declaration, Ağırnas will be introduced with it's natural and cultural qualities, landscaping features and urban characteristics. Then, housing areas & houses of Ağırnas are going to be evaluated in the frame of ecological design criteria. Besides, proposals for the sustainability of the ecological, spatial and socio cultural values of the local character & the settlement is offered.

**Keywords:** Ağırnas, traditional settlements, traditional Anatolian houses, ecological design, landscape design

## INTRODUCTION

Mankind imitated nature while interfering nature in their physical surroundings throughout history. They used basic natural and local building materials that was supplied easily from their near environs (Erdoğan & Yıldız, 2017). Environmental conditions and the local structure are the main determinants in the formation of the traditional architectural character. Stone and timber are the most commonly used building material from prehistoric times to today as easily accessible, robust, recyclable, environmentally sensitive building materials that can easily obtained from local sources.

Most of the monumental buildings erected by different civilizations were built with stone and timber with different methods according to their usage have reached today.

However, cultural environments are faced with danger such as lack of care, abandonment as a result of the changing World so that cultural landscapes are transforming due to various reasons and the mostly effected areas are the traditional mostly effected areas are the tranditional urban environments that are facing with dense building activities and urban developments. In this context, the effective use of resources and ecological design concepts with the aim of sustainable ecological design principles in traditional settlements are on agenda.

Nature-based ecological design can be expressed as an environmentally sensitive design approach aiming the efficient use of natural resources and the creation of optimum environmental conditions for living things in case of space organisation (Aklanoğlu, 2009). Ecological design is an organic and holistic approach that is primarily based on human health and human ecology. However, it's integrative and environmentally harmonious phenomenon using recources&building material efficiently in order to transfer them to future generations.

As the result of technological developments there are radical changes in urban environments and building activities giving harm to nature. So, the design principles of traditional settlements that were easily integrated with nature are taken into consideration in the design of actual urban environments. The spaces that contributed to the urban identity providing the integration of the city with the natural environment will be created by use of these criteria. In addition to the natural and cultural values of the historical cities, the preservation of the memorial and symbolic values they carry and their transfer to future generations is a necessity. The ecological, spatial and sociocultural sustainability of traditional settlements will be ensured by spanning the planning and design processes on ecological basis and the application of nature friendly design approaches.

Traditional/vernacular architecture having historical identity consists features that are shaped due to the environmental conditions throughout history protecting urban ecology, and compatible with energy efficient design principles (Tel Öztürk & Erdoğan, 2014). The most important reasons why settlements belonging to historical periods reached today is the way that they are utilizing the construction technology of their period using natural building material and environmental sources effectively (Tel Öztürk, 2014). In this context, Ağırnas Town which is a sub-settlement of Kayseri has traditional/vernacular houses built with stone by using environmentally conscious natural building materials protecting natural resources to a great extent.

In this decleration, first of all Ağırnas Town was introduced with it's natural&cultural values, landscape features were introduced. Than, urban fabric of Ağırnas&the vernacular houses were evaluated&criticised as far as local identitiy&design principles are concerned. And finally suggestions were offered for the settlement both in planning & design scales due to the urban&building analysis studies.

## MATERIAL and METHOD

The main material of the research in Ağırnas Town is first degree urban and archaeological sites declared by the decision of the Regional Board for the Protection of Cultural and Natural Assets of Kayseri, dated 30.05.2002 and numbered 3018. Ağırnas is a sub-settlement of Kayseri situated in the middle Kızılırmak section of Central Anatolia Region (Figure 1), 26 km north-east of Kayseri Province, within the boundaries of Melikgazi District, 35° 31' east longitude and 38° 43' north latitude (Anonymous 2017a).

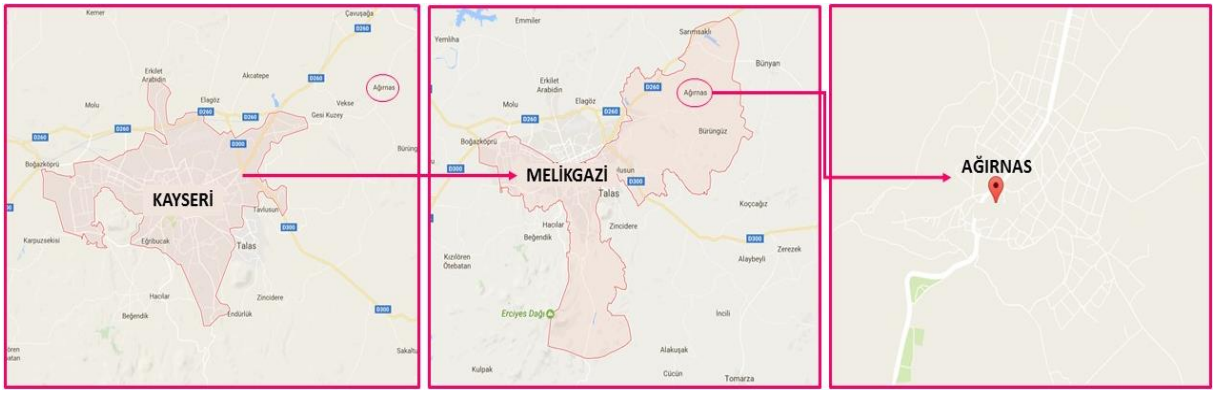


**Figure 1.** Ağırnas, geographical location (Anonymous 2017b).

Ağırnas, which is selected as the study area; is an Anatolian settlement built with traditional Ağırnas stone, that is situated on a rocky valley on the southern slopes of the Koramanlar Valley. The residential area is located above the underground cities formed by rock carved structures on the northern slopes of the valley in the vicinity of Ağırnas. Ağırnas is an important ecological source within the context of the microclimatic effects and the natural landscape characteristics; having the potential to sustain its presence as a sustainable settlement in the future near the Kayseri province and its ecological character has been effective in choosing the research area. The method used in the research has mainly three stages. At the first stage, natural, cultural values & landscape features of Ağırnas&it's near environs were introduced. At the secoond stage, national and international sources were evaluated in cases of ecological design, local identitiy and preservation of cultural landscapes. Besides, site analysis studies were held to determine the current situation, problems and potentials of the area and the reconstruction plan of Ağırnas at 1/1000 scale for the protection of the area obtained from the municipality of Melikgazi was searched. At the final stage, the present situation of Ağırnas Town; the urban facric and stone masonary houses were criticised in the frame of ecological design and evaluated according to EU Sustainability indicators to set the requirements indicated. Then, suggestions have been developed with the aim of ensuring the sustainability of ecological, spatial and socio-cultural values of Ağırnas Town.

## RESULTS and DISCUSSION

In this section, Ağırnas Town was introduced with its natural, cultural characteristics and traditional settlement pattern and Ağırnas houses built with cut-stone were evaluated within the scope of EU Sustainability indicators and ecological design criteria.

### Natural Landscape Properties of Ağırnas Town

Although Ağırnas is a hot-arid climatic region which is cold and snowy in winter, warm and dry in summer with the influence of the Erciyes Mountain. It is a rural settlement where also a plateau climate is observed depending on its location. The warmest month is July whereas the driest month is August in the region with an annual average temperature of 18.9ºC in which annual rainfall is 7 mm per $m^2$ (Anonymous 2017c). Erciyes Mountain located 54 km south west of Ağırnas is active 5-6 million years ago for about 100 years, is the highest mountain of Central Anatolia. Today, basalt and andesitic rocks as well as tectonic depression and elevated areas and 300 m thick volcanic tuff rock structure in yellow and white colors are present around 15.000 $km^2$ of the inactive volcanic mountain (Okyay, 2007).

Local yellow stones, which are easily shaped and easily carved for such stone work and decoration, have also been used in the traditional Ağırnas dwellings. Ağırnas settlement in Koramanlar Valley where the Akbin (Değirmenler) stream bed, flowing in the southeast-northwest direction, does not contain forests; there are rather sparse shrubs and grasslands in the depression basins and on the plain. In the region, there are often group of steppe plants that contain geven grass, shepherd's cushion, moss, lambs, cattle tails and poppy species. In other parts of the region, fruit trees, ash, linden, poplar and willow species as well as bushes are also encountered (Anonymous 2016).

**Cultural Landscape Properties of Ağırnas Town**

It is thought that the settlement history of Ağırnas goes back to the Late Hittite Period according to the data ontained from the archaeological excavations in the tumuliuses and underground cities. Communuties that have lived in Ağırnas throughout history have designed urban spaces and traditional houses using yellow colored Ağırnas stone and timber with local construction technique which is stone mansonary. As the area has been used as a settlement by different civilizations, the urban patterns were superimposed one another such as caves, underground cities, churches, and stone mansonary houses on the north side of the Koramanlar Valley which is a first degree urban site. Meanwhile, original traditional Ağırnas houses built with cut stone were located on the southern slopes of the valley (Figure 2).


**Figure 2.** Ağırnas, traditional settlement texture (Original 2014)

Traditions, beliefs, local conditions, volcanic rock formations, climatic conditions, topographical structure have influenced Ağırnas' natural and cultural landscaping character as well as the formation of traditional settlement texture. Beginning from the southern slopes of the valley, the structures, streets and neighborhoods in accordance with the topographical characteristics and in organic form extends gradually towards the center of Ağırnas. There are 31 registered buildings consisting of church, residences, school buildings, “bezir seteni” (fabric production building), fountain and prayer hall within the boundaries of the Ist and IIIrd degree urban and archaeological sites. The streets, which are bounded by courtyards and garden walls of two to three storey houses were shaped and shaped by the cantilivers and balconies of the houses, are creating an organic texture that narrows and expands.

The most important open spaces that provide active and passive recreation opportunities to the local people are the squares that were formed by the intersection of streets

embellished with fountains in the urban texture. It is also possible to see "dead-end street" applications in the neighbourhoods where Ağırnas (tuff) stone is used as covering material.

The traditional street structure, shaped due to the topography in an organic form, has been closed down from its extreme points to ensure privacy and security, so that the street closed to general use has been turned into a special area for the use of a particular housing group. Streets are running parallel to the topography on the west-cast direction whereas the houses were erected on the worth-south direction to supply both sunshine to the houses as well as qualified vantilation.

The enterances of the houses to the courtyard were mostly supplied from north direction. On the other hand, the spaces of the houses were oriented to south in harmonious with the topography. The high walls of the courtyards provides houses both from sunshine during the summer months and cold winds during the winter. Besides, houses were built according to the dominating wind direction to supply air circulation&the inner spaces of the houses.


**Figure 3.** Traditional houses of Ağırnas (Original, 2014)

Because of the geological rock formations of the region, the volcanic tuff stone (Ağırnas stone) was used as building material and the floor coverings of the houses and on the courtyard walls. The near environs of Erciyes Mountain are rich in volcanic tuff rocks, which has a great load bearing capacity and suitable for carving. Especially in Ağırnas, tuff rocks have been used in the construction of caves, underground cities and traditional Ağırnas houses throughout history because of it's easily processable nature.

Ağırnas stone is a tuff stone that has hardened after contacting with air and has a high resistance to cold weather conditions. Besides, this type of stone, which is an effective material in terms of insulation, ensures that the interior is warm in winter, and cool in summer. Thus, use of technologies such as air conditioners and refrigerators and their harmful effects to environment are eleminated. Therefore, it brings the effective user of energy as well as environmentally sensitive ecological design.

The number of open-green areas designed in the traditional city of Ağırnas, which is positioned according to the natural landform, is not much. However, in the Koramanlar Valley, the green vegetation around the Akbin Stream and its surroundings have an important potential in terms of ecology and recreation. The gardens and courtyards of the houses and the fruit gardens located on the south side of the settlement center constitutes the present green areas of Ağırnas. The surroundings of the Agios Prokopios Church and the Ağırnas Library were arranged as a green area after the restoration of the buildings (Figure 4).

**Figure 4.** Koramanlar Valley, Agios Prokopios Church and Ağırnas Park (Original, 2014)

**The Evaluation of Ağırnas Town in the Frame of Sustainability Criteria of European Union (EU)**

The main evaluation criteria for Ağırnas Town is the sustainability criteria of European Union (Aklanoğlu & Erdoğan, 2011) and it's checklists. So that, Ağırnas traditional settlement pattern was evaluated in this context (Table 1).

**Table 1.** The Evaluation of Ağırnas Town in the Frame of Sustainability Criteria of EU

| EU Criteria | Current Situation of Ağırnas |
|---|---|
| Sustainable Land Use | 3006 inhabitants are living in Ağırnas. The settlement, buildings & landscape application have been developed according to the land form. The houses were integrated successfully as far as wind-direction, sun, topography, climatic factors & flora of the area are concerned. So that, the land was used effectively. Houses were built on the rocky land on the north side of Koraman Valley whereas agricultural lands, fruit gardens & the cemetery are located on the south side of the settlement area. Ağırnas Town fulfill the requirements of a sustainable settlement by it's textural qualities, topographic uses, agricultural lands supplying the food of the inhabitants and effective land use. |
| Traditional Houses | Houses were built with local cut stone mansonary supplied from the region very easily which is an excellent insulator building material which can be considered as energy efficient. Besides, courtyards located in the centre of the houses used as the main space organizers act as microclimatic regulisators both in summer & winter months. |
| Transportation and the accessibility to public spaces & facilities | Residental areas are situated very near the town center. So that, accessible to all facilities such as commerce, educational & health services as well as open green areas by pedestrians. So, there is no need for public transportation. However, Kayseri-Ağırnas Highway is passing through the I. Degree Archeological Site into two sections, and giving harm to the urban tissue. Vehicle traffic accessibility is good in the traditional settlement area supplied by narrow street pattern. The area is also suitable for bicycle transportation; however, it is not common in the town. |
| Air Quality | There is no measurement done in the town to determine the air qualitiy. However, there is no industrial activity in the region as well as vehicle traffic to produce air pollution. Besides, the valley located on the south side of the settlement polluted air is transferred from the area by the help of the air corridor. |
| Waste Management | Wastes of the town are transfered to solid waste disposal area. Waste water is also drained to the sewage system. On the other hand, there is no recycling or waste cycling applications in the town. |
| Noise | There is no noise source in the settlement and it's near environs originating either from industry or traffic. Silence is one of the main characteristics of the area. |
| Sustainable Management of Local Authorithies | There are some building & landscape activities in the town. Open green system of the settlement is supported with new design activities to upgrade the quality of the settlement. There are also restoration & rehabilitation activities in the 1st. Degree Archeological Site Area of Ağırnas. Heavy vehicle traffic is forbidden in the protected area to restrict the damage in the historical environment. Besides, the house of Architect Sinan was restored as well as his ? |
| Utilities supporting sustainability | There are many local Arts & crafts activities in the town such as stone mansonary, stone carving activities, carpets, rugs, coppersmith, plastering. All these handcrafts and local artistic activities are supporting the sustainability and economy of the settlement. |
| Local participation for ecology | There is no special organisation or application related to public participation. However, local people are very sensitive to the ecology & the environmental resources. |
| Energy | Local building material which is a volcanic rock is an excellent insulator. So that, the buildings are warm in winter & cold in summer months for energy saving and there is no need for extra climatization devices. Besides, hot water is supplied by the help of solar energy. On the other hand, underground structures & rock carved buildings are used as cold storage spaces for foods. Consequently, the settlement has a great energy saving capacity which is one of the main objectives of an ecological design. |
| Use of Technology | There is no high technology in the settlement. However, basic technological requirements are fulfilled such as all electronic devices, cellphones & internet communication are available. |

## CONCLUSION

According to the research findings & site analysis studies; it is determined that Ağırnas is carrying all the qualities of an ecological settlement. The town is situated and developed according to the natural environmental factors in harmony with the existing topography. The building density in the urban tissue is low and in human acale with it is 2-3

story buildings. Besides, every building has its own open green space either in the form of courtyards or gardens whih supplies private.

Open spaces to all buildings as well as it's psychologial & aesthetical values. However, the open and green areas needs aesthetical design approaches to improve the quaility of the urban green areas. There is no comprehensive restoration activity in the registered traditional settlement area. Besides, some of the buildings that were restored are not qualified and some are in ruins. There are huge gaps in the construction plan prepared for the protection of the traditional settlement causing harm in the urban tissue in cases of ruined buildings and undetermined open spaces in the area. On the other hand , new building activities and attached spaces to the original houses done unconsciously cause harmful visual effects and damage to the original strect patterns, plan schemes & facades of the stone mansonary buildings. There is no conservation decision or proposal as far as open green areas, squares and plant material are concerned.

Furthermore, the underground cities located under the traditional settlement of Ağırnas restricts the plantation applications in the area. On one other hand, active urban green spaces that take place both in Koramanlar Valley and the town center are not distributed homogenously; on the other hand, sport facilities and related areas are insufficient.

Consequently, Ağırnas historical city centre and the traditional houses are carrying the criteria of ecological design which was shaped due to natural and cultural values of the region synthesized throughout centuries. However, new urban development & housing areas are disregarding these criterias. So that, new development areas attached to the traditional center and the buildings should be designed and built according to environmental factors and building material as well as actual needs of daily life.

In this context ecological design criteria for Ağırnas is as such:

- The conservation plan prepared for the Town of ağırnas should be sevised in order to protect the existing environmentally friendly ecological urban tissue & vernacular houses of the region.
- Biological diversity & ecological richness of Koramanlar Valley and it's near environs and the urban air quality must be protected, and improved by means of planning approaches & legistation.
- The agricultural lands located on the southern side of the traditional settlement must be protected to sustain their function and construction activities in these lands & it's near environs must be forbidden legislatively.
- Only local stone should be used both in the traditional urban tissue of Ağırnas and the street coverings. Besides, sewage & drainage system of the town should be improved.
- Traditional Ağırnas houses that needs repair should be restored with convenient restoration approaches & techniques.
- All the buildings & houses should be restored with respect to their original plan schemes, facade elements building material and construction technique.
- The buildings lost their functions should be refunctioned and rearrangened accordingly in a conservative approach.
- Ruined buildings in the vernacular urban tissue should be rehabilitated urgently. They can either be reintegrated or consolidated according to the data obtained.
- Landscaping or plantation in the traditional settlement should be combined with the cultural values and plant material that is going to be used should be selected from the species of natural local vegetation of the region.

- As there are underground cities under the vernacular settlement area; infrastructural applications & plantation should be done carefully in order not to give harm to the underground cultural assests.
- An integrative planning and design approach carved underground cities monumental buildings, stone mansonary houses & plantation of the urban tissue to protect the urban silhouette & cultural landscape proporties as well as original structural character of the town.
- The underground cities should be rehabilitated and consolidated to strengthen the carved structures and to keep it's originality.

As Ağırnas is a unique settlement with all it's urban and natural components; it must be preserved with special techniques to sustain the settlement and to transfer it to future generations with it's ecological, local, structural, traditional and aesthetical values.

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## REFERENCES

Aklanoğlu, F. 2009. Geleneksel Yerleşmelerin Sürdürülebilirliği ve Ekolojik Yerleşmeler. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü Peyzaj mimarlığı Anabilim Dalı, 222, Ankara.

Aklanoğlu, F. & Erdoğan, E., 2011. Sille (Konya) Yerleşiminin Sürdürülebilirliği için Ekolojik Tasarım Önerileri. Tekirdağ Ziraat Fakültesi Dergisi, 8 (2): 119-133.

Anonymous 2016. Web Site: http://www.kayserikulturturizm.gov.tr (accessed: 15 February 2017).

Anonymous 2017a. Web Site: http://www.haritatr.com/harita/agirnas/102685 (accessed: 10 February 2017).

Anonymous 2017b. Web Site: https://www.google.com.tr/maps/place/Kayseri (accessed: 23 February 2017)

Anonymous 2017c. Web Site:http://kayseri.tarim.gov.tr/Menu/80/Cografi-Yapi (accessed: 15 February 2017).

Erdoğan, E. & Yıldız, N.E., 2017. Peyzaj Tasarımı ve Taş. IV. Uluslararası Taş Kongresi Özet Kitabı, 20-25 Mart, pp.62-64, İzmir.

Okyay, A., 2007. Ağırnas Kentsel Sit Alanı ve Mimar Sinan Caddesi Üzerine Bir Araştırma. Yıldız Teknik Üniversitesi Fen Bilimleri Ensitüsü Mimarlık Bölümü Rölöve-Restorasyon Anabilim Dalı, 172, İstanbul.

Tel Öztürk, H., 2014. Şanlıurfa Geleneksel Kent Dokusunun Ekolojik Tasarım Kapsamında Değerlendirilmesi. Doktora Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü Peyzaj Mimarlığı Anabilim Dalı, 257, Ankara.

Tel Öztürk, H. & Erdoğan, E. 2014. Ekolojik Yerleşmeler ve Ekolojik Yıpranma: Şanlıurfa Geleneksel Kent Dokusu ve Karaköprü İlçesi. KSÜ Doğa Bilimleri Dergisi, 17 (2): 21-32.

EURASIAN JOURNAL OF AGRICULTURAL RESEARCH

# Molecular Identification of Sooty Molds on Wheat Fields in Central Anatolia Region and Effect of Seed Germination

***Filiz Ünal[1], Emel Çakır[2]**

[1,2] Plant Protection Central Research Institute, Ankara, Turkey

*Corresponding Author: filiz.unal@tarim.gov.tr

## Abstract

Surveys were conducted in wheat growing areas of Konya, Ankara, Eskişehir, Yozgat, Kayseri, Kırıkkale, Kırşehir, Aksaray, Nevşehir provinces in 2011-2012 growing seasons in Central Anatolia Region, Turkey. Black heads and black spots on leaves were seen especially during late surveys and the contamination rate in these fields was observed between 40-100%. Thirty six wheat samples were collected from the fields. As a result of isolation from heads, leaves and grains, 88 'Sooty Mold' isolates were obtained belonging to 5 different fungus genus. These fungi cause, known as black point, damage (discolored) grain which affect quality and marketability. In consequence of morphologic identification and DNA sequence analysis, isolates obtained from infected black heads and leaves were determined as *Alternaria alternata, Alternaria. chlamydosporigena, Alternaria infectoria, Alternaria quercus, Alternaria tenuissima, Alternaria triticina, Cladosporium cladosporioides, Cladosporium herbarum, Cochliobolus sativus, Epicoccum nigrum* and *Stemphylium sp.* The isolations were made from the grains observed black point, *A. alternata, A. infectoria, A. tenuissima, A. triticina, Cochliobolus sativus, Cladosporium cladosporioides, C. herbarum, Epicoccum nigrum* and *Stemphylium sp,* were determined. The most prevalent species was found as *Alternaria alternata* in the fields. In each wheat cultivar tested in inoculated seeds significantly reduced their germination.

**Keywords**: Sooty molds. Black head, Wheat, Molecular, Germination

## INTRODUCTION

Wheat is the most important cereal crop of Turkey is grown extensively in provinces of Central Anatolia Region. In field, wheat is attacked by a lot of different sooty mold fungi, which under certain climatic conditions significantly reduce the yield and quality of the crop. Sooty molds are caused by a large number of weakly parasitic and saprophytic fungi, especially species of *Cladosporium, Alternaria* and *Cochliobolus* and these fungi are seed-borne and transmitted through seeds (Bockus, 2010; Anonymous, 2010) and cause black point symptom. Black point is one of important disesase in Central Anatolia Region. Black point defined as the discoloration of the embryo end and surrounding areas of the wheat kernel, occurs any time from grain filling to near harvest. High humidity or frequent rainfall from milk to soft dough stage, late season irrigation often stimulate infection by sooty mold fungi. The various fungal organisms associated with wheat, members of black point complex not only reduce germination and vigor of wheat seed but also cause seedling blight disease in the world (Khanum *et al*., 1987; Rahman & Islam, 1998; Perello *et al.,* 2005, 2008; Rajput *et al*., 2005; Fakhrunnisa & Gaffar, 2006).

Because of black discoloration and lower germination of the black point that is affected seeds, the seed agencies like Turkish Grain Board (TMO) and some seed companies have often been rejecting considerable quantity of wheat seeds inflicting significantly economic loss in Turkey. Black point symptoms are caused mainly by *Alternaria alternata, Cladosporium cladosporioides, Bipolaris sorokiniana* and *Epicoccum* sp. (Fakir *et al*., 1989; Mathur & Cunfer, 1993) Some species are pathogen of leaves and seeds or rarely of stems and roots of plants from different families. *C. sativus* causes disease on the root, leaf, stem, and head tissue (Anonymous, 2010) and *A. triticina* causes leaf blight on wheat leaves (Perello & Sisterna, 2006). Optimal conditions for infection growth are high relative air humidity and temperature about 20-25.$^0$C (Chelkowski & Visconti, 1992).

Literature reviews show that no work on survey and the prevalence of the sooty molds on leaves and heads in fields in Turkey. There are some literature about only black point on grains in the other Regions of Turkey (Biçici & Çınar, 1988; Özer, 2005). This study is aimed to identify sooty molds in wheat fields in 9 Central Anatolia Region Provinces and investigate *in vitro* germination rates of with black point seeds of wheat.

## MATERIAL and METHOD

### Sample Collection

In order to determine the sooty molds associated with black spotted leaves and black heads of wheat (Figure 2) in Central Anatolia Region, Turkey (Figure 1). Thirty six samples in black heads and black spotted leaves were collected in 2011 and 2012 growing seasons. Samples were taken from Konya, Ankara, Yozgat, Eskişehir, Kayseri, Kırşehir, Aksaray, Nevşehir and Kırıkkale provinces. Black point symptoms were observed only from 20 seeds.

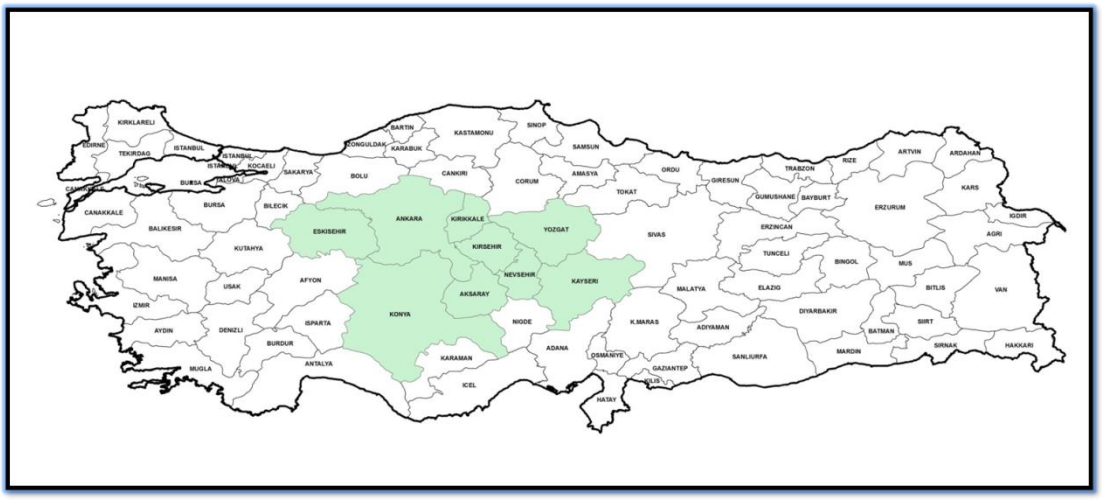


**Figure 1.** Location of survey areas in Central Anatolia Region

**Figure 2.** Symptoms of 'Sooty Molds'on heads and leaves

## Isolation and Identification of Fungi

Segments of sooty leaves were surface sterilized for 1 min, glummed black grains and unglummed grains with black point (Figure 3) were surface sterilized for 3 min in 1% sodium hypochlorite (NaOCl) solution and then washed thoroughly with sterile water and air dried in a laminar flow hood prior to placed on potato dextrose agar (PDA, Merck, Germany) containing 50 mg/l streptomycin sulfate and blotter. Ten seeds were placed on each plate and five petri dishes were used for each sample. Then dishes were incubated under a combination of long-wave ultraviolet and fluorescent light (12 h light: 12 h dark) for 7 days. Temperature was kept 20ºC under the light and dark regimes, respectively. After 7 days of incubation, individual seeds and leaves were examined under a stereomicroscope and light microscope for the presence and absence of fungi. Morphological identification of fungi were confirmed by examining for the presence of mycelia and/or conidia under light microscope. The fungal species present on each of the seeds and segment of leaves were recorded. The fungi were stored at 4ºC and -80ºC. The identification of fungi genus was made taking into consideration sporulation, conidiophore structure and conidium size, shape and surface ornamentation using following the keys offered by different authors Ellis, 1971 and J. Chelkowski and A. Visconti, 1992 (Identification were done using 'Alternaria, Biology, Plant Diseases and Metabolites). Identification of fungi species was made according to DNA sequence analysis.

**Figure 3**. Grains with black point

**Molecular Identification**

The ITS regions of the isolates were amplified using the universal primers ITS-1 (5' TCC GTA GGT GAA CCT GCGG 3') and ITS-4 (5' TCC TCC GCT TAT TGA TATGC 3') as described by White *et al*. (1990). Genomic DNA was extracted using a Qiagen DNeasy ® Plant Mini Kit, as specified by the manufacturer, and stored at -20°C prior to use. PCR reaction mixtures and condition were modified from previous studies (Acora & Raposo, 2007; Cobos & Martin, 2008). The reaction mixtures of PCR, a final volume of 50 µl, contained 5µl of 10X buffer [75 mM Tris HCl, pH 9.0, 50 mM KCl, 20 mM (NH4)2SO4], 2 µl of 5 µM each primers, 5 µl of 1.5mM MgCl2, 2 µl of 10 mM deoxynucleoside triphosphates (dNTPs), 1 U Taq polymerase (Fermentas), 5 µl of DNA template for each reaction and 5 µl of bovine serum albumin (BSA: 10 mg/ml). DNA amplifications were carried out in a Techne TC-5000 thermal cycler by the following program: 94 °C for 2 min, followed by 34 cycles of (1) denaturation (94˚C for 30 s), (2) annealing (60˚C for 30 s) and (3) extension (72 °C for 30 s), and a final extension step 10 min at 72°C. The PCR products were separated in 1.5 % agarose gels stained with ethidium bromide, and visualized under UV light. They were sequenced by GENOKS (Gene Research and Biotechnology Company, Ankara, Turkey). The nucleotide sequences were subjected to Basic Alignment Search Tool (BLAST) analysis (http://www.ncbi.nlm.nih.gov) and compared to other sequences in GenBank.

**Germination Tests**

*In vitro* germination rate tests were conducted in order to determine the effect of the 18 isolates. Two isolates of each fungi species isolated from mycoflora associated with the seeds were used on Bezostaja, Tosunbey and Gerek 79 wheat cultivars which commonly grow in this Region. Seeds of cultivars were surface disinfected with 1% sodium hypochlorite (NaOCl) solution for 3 min. and then they were washed three times with distilled water. The seeds were allowed to air dry for 24 h under a laminar flow hood. The seeds were inoculated by immersing in a standarized solution containing spores at a concentration of $3x10^5$ spores/ml of the 18 species isolated from with black point grains. The seeds were sown in 9 cm diameter Petri dishes on three layers of blotting paper and water agar. Each plate was moistened with 4 mL of distilled water. Twenty seeds in each plate were spread at a regular distance on the surface of the paper. Five plates were used. The Petri dishes were covered with a plastic bag to prevent drying and they were incubated. Incubation was at 20ºC for 7 days with 12 h of alternating cycles of NUV (near ultraviolet) light and 12 h darkness. After incubation seeds were examined and germination percentages were recorded. Germination was considered present when the radical protrudes by 2-4 mm was observed (Perello & Larran, 2013). Disinfected seeds were used as control. Percentages of colonization of seeds were also calculated each media and the average is calculated.

## RESULTS and DISCUSSION

The number of 88 'sooty mold' fungi were detected that were recovered from 36 wheat samples collected from Konya (10 samples), Ankara (8 samples), Eskişehir (3 samples), Yozgat (5 samples), Kayseri (1 samples), Kırıkkale (3 samples), Kırşehir (3 samples), Aksaray (2 samples), Nevşehir (1 sample) Provinces. In consequence of morphologic identification and DNA sequence analysis, isolates obtained from black heads and infected leaves were determined as *Alternaria alternata, Alternaria. chlamydosporigena, Alternaria infectoria, Alternaria quercus, Alternaria tenuissima, Alternaria triticina, Cladosporium cladosporioides, Cladosporium herbarum, Cochliobolus sativus, Epicoccum nigrum* and *Stemphylium sp.* (Figure 4).

The isolations were made from the grains observed black point, *A. alternate, A. infectoria, A. tenuissima, A. triticina, Cochliobolus sativus, Cladosporium cladosporioides, C. herbarum, Epicoccum nigrum* and *Stemphylium sp,* were determined. Identified species showed 95-100% similarity with the isolates belong to same species in NCBI. Our results agree with other reports, in a study conducted in China, 1458 isolates obtained from the leaf samples of winter wheat collected from 7 main wheat production areas in Shandong Province were identified as 25 species in 18 genera belonging to sooty moulds pathogens i,e. *A. alternata*, *Aureobasidium pullulans*, *Cladosparium cladosporides*, *C. oxysporium*, *C. herbarum*, *C. sphaerosporum*, *Epicoccum nigrum* and *Stemphylium botryosum*. *A. alternata* and *Cladosporium* spp.were predominant species in all areas investigated (Lixin *et al*., 1994). In England, Flag leaves and ears of spring wheat cv. Timmo and winter wheat cv. Maris Huntsman in 1981 and 1982 were colonised by a variety of micro-organisms whose numbers increased rapidly between anthesis and harvest. The predominant mycoflora were yeasts, yeast-like fungi and filamentous fungi which included *Cladosporium* spp., *Verticillium lecanii, Alternaria alternata, Fusarium* spp. and *Epicoccum nigrum* (Magan & Lacey, 1986).

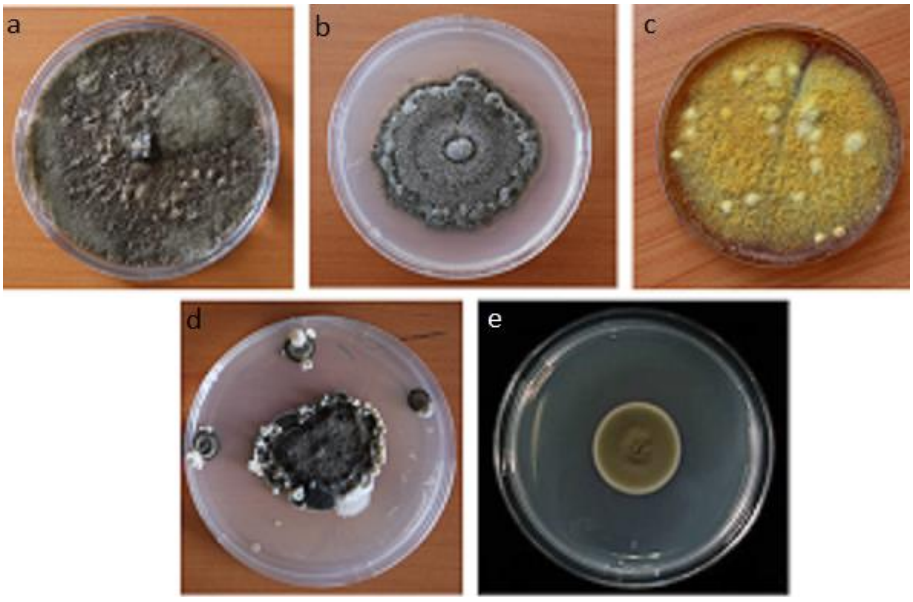


**Figure 4**. Sooty mold Fungi on PDA, (a) *A. alternaria*, (b) *A. tenuissima*, (c) *E. nigrum*

(d) *C. sativus*, (e) *C. cladosporioides*

Members of *Alternaria* species were found dominant flora with the number of 42 isolates. *Alternaria alternata* was found dominat species from isolated leaves and black heads, while *Alternaria tenuissima* was found from isolated black point grains (Table 1). *Alternaria alternata* is ubiquitous and abundant especially during ripening and harvesting of cereal crops. Ripening ears of wheat are colonized by *A. alternata* soon after emergence and it is also reported to be the most common subepidermal fungus of wheat grain (Hyde & Galleymore, 1951). *A. alternata* alone or with other fungi, e.g., *A. triticina, A. tenuissima* can cause a conspicuous black or brown discoloration of wheat kernels called black-point disease (Bhowmik, 1969). This can result in decreased quality and yield of grain (Dickinson, 1981; Dash & Narain, 1989; Chalkley, 2012). Our results agree with other reports on the vast majority of *Alternaria* strains either *A. tenuissima* or *A. alternata* as a dominant species on black pointed kernels (Özer, 2005; Perello & Larran, 2013). This group is important in terms of the deterioration of wheat sub-products and the risk of harmful mycotoxins production. Five *Alternaria triticina* isolates were obtained from leaves, glummed black grains, unglummed grains with black point.

*A. triticina* also causes leaf blight on wheat. 7 virulent *Cochliobolus sativus* fungi were isolated. There are no studies related to 'sooty molds' on wheat fields in Tukey. The study conducted in Tekirdağ, Turkey, *Alternaria alternata* was the dominant fungus in black pointed kernels for both years and isolated from the endosperm and seed coat especially, but present at low level (Özer, 2005). In consequence of isolations from grains, 5 isolates were identified as *Fusarium culmorum* and 3 isolates were identified as *F. graminearum, 2 isolates were F. nivale* in this study. *A. chlamydosporigena* and *A. quercus* were not isolated from grains while they isolated from leaves and heads.

**Table 1.** Species, origin and number of sooty mold fungi isolated from wheat leaves, heads and grains

| Fungi | Source of isolation | Number of Isolate | Origin |
|---|---|---|---|
| ***Alternaria alternata*** | Leaf, black grains (with glume), grain (with black point) | 18 | Konya, Ankara, Eskişehir, Yozgat, Kayseri, Kırıkkale, Kırşehir, Aksaray, Nevşehir |
| ***Alternaria tenuissima*** | Leaf, black grains (with glume), grain (with black point) | 11 | Konya, Ankara, Eskişehir, Yozgat, Kayseri, Kırıkkale, Kırşehir, Aksaray |
| ***Alternaria infectoria*** | Leaf, black grains (with glume), grain (with black point) | 5 | Konya, Ankara, Yozgat, Kırıkkale |
| ***Alternaria chlamydosporigena*** | Leaf, black grains (with glume) | 1 | Ankara |
| ***Alternaria quercus*** | Leaf, black grains (with glume) | 2 | Konya, Ankara |
| ***Alternaria triticina*** | Leaf, black grains (with glume), grain (with black point) | 5 | Konya, Ankara, Yozgat, Kırşehir |
| ***Cladosporium cladosporioides*** | Leaf, black grains (with glume), grain (with black point) | 10 | Konya, Ankara, Eskişehir, Yozgat, Kayseri, Kırıkkale, Kırşehir, Aksaray, Nevşehir |
| ***Cladosporium herbarum*** | Leaf, black grains (with glume), grain (with black point) | 8 | Konya, Ankara, Eskişehir, Yozgat, Kırıkkale, |
| ***Cochliobolus sativus*** | Leaf, black grains (with glume), grain (with black point) | 7 | Konya, Ankara, Eskişehir, Yozgat |
| ***Epicoccum nigrum*** | Leaf, black grains (with glume), grain (with black point) | 15 | Konya, Ankara, Eskişehir, Yozgat, Kırıkkale |
| ***Stemphylium sp,*** | Leaf, black grains (with glume), grain (with black point) | 6 | Konya, Ankara, Yozgat |

Differences were observed for seedling emergence of wheat as affected by inoculation of different sooty-mold fungi (Table 2). The controls which belong all cultivars without inoculations showed normal seedlings (100% germination). *A. alternata* was the dominant species in terms of seed colonization. *C. sativus* infected a high percentage of wheat grains. Seed colonization ranged from 88-98% by *A. alternata* and range from 90-92 by *C. sativus*, whereas seed germination was ranged from 45-78% by *A. alternata* and from 20-48% by *C. sativus.* It was determined that *A. tenuissima* and *A. alternata* have the highest colonization rate among *Alternaria* species and they affected germination.

Similarly, in Pakistan, *Alternaria spp* were detected as predominant causing 82% reduction in germination of wheat seeds and also affecting seedling vigor (Rajput *et al*., 2005). *A. tenuissima* can infect a high percentage of cereal grains (Andersen & Thrane, 1996; Kosiak *et al*., 2004; Gannibal *et al*., 2007) producing some toxins dangerous for plant, animals and human health (Andersen *et al*., 2002). A study was conducted by Perello & Larran (2013), *A. tenuissima* was the dominant species with a seed colonization ranged from 86-99%, following by *A. infectoria* (79-85%) and *A. A. triticina* (68-71%). On the contrary our study, seed colonization ranged from 20-49% by *A. alternata*. *Alternaria alternata* is ubiquitous and abundant especially during ripening and harvesting of cereal crops. Ripening ears of wheat are colonized by *A. alternata* soon after emergence, and it is also reported to be the most common subepidermal fungus of wheat grain (Hyde & Galleymore, 1951). *A. alternata* alone or with other fungi, e.g., *Alternaria triticina*, can cause a conspicuous black or brown discoloration of wheat kernels called black-point disease (Bhowmik, 1969). This can result in decreased quality and yield of grain (Dickinson, 1981; Dash & Narain, 1989; Chalkey, 2012). *Epicoccum nigrum* was second species following *Alternaria* spp.with 93-95% seed colonization rate but germination ranged from 75-92% by *E. nigrum.* Germination rate of bezostaja cultivar was found more than other cultivars. The lowest germination rate was observed by *C. sativus* on Gerek 79 cultivar with 20%. Reductions in germination were observed on all inoculated petri dishes compared to control dishes.

**Table 2.** Percentage of colonization seed and effect on germination wheat seeds cultivar Bezostaja, Tosunbey and Gerek 79 of 18 members of sooty mold

| Sample Numbers | Fungi | Province | Seed Colonization (Average) (%) | Seed Germination (%) | | |
|---|---|---|---|---|---|---|
| | | | | Bezostaja | Tosunbey | Gerek 79 |
| Aa1 | *A. alternata* | Konya | 98 | 78 | 50 | 45 |
| Aa2 | *A. alternata* | Nevşehir | 88 | 67 | 58 | 54 |
| At1 | *A. tenuissima* | Konya | 86 | 56 | 47 | 62 |
| At2 | *A. tenuissima* | Yozgat | 99 | 58 | 42 | 56 |
| Ai1 | *A. infectoria* | Kırıkkale | 79 | 75 | 60 | 45 |
| Ai2 | *A. infectoria* | Yozgat | 85 | 80 | 55 | 60 |
| Atr1 | *A. triticina* | Kırşehir | 68 | 42 | 50 | 52 |
| Atr2 | *A. triticina* | Ankara | 71 | 65 | 68 | 70 |
| Cc1 | *Cladosporium cladosporioides* | Kayseri | 75 | 68 | 44 | 65 |
| Cc2 | *Cladosporium cladosporioides* | Nevşehir | 88 | 70 | 85 | 62 |
| Ch1 | *Cladosporium herbarum* | Eskişehir | 79 | 75 | 70 | 69 |
| Ch2 | *Cladosporium herbarum* | Kırıkkale | 69 | 69 | 58 | 65 |
| Cs1 | *Cochliobolus sativus* | Ankara | 90 | 48 | 35 | 20 |
| Cs2 | *Cochliobolus sativus* | Eskişehir | 92 | 38 | 25 | 40 |
| En1 | *Epicoccum nigrum* | Konya | 95 | 80 | 75 | 92 |
| En2 | *Epicoccum nigrum* | Yozgat | 93 | 84 | 76 | 79 |
| St1 | *Stemphylium sp,* | Ankara | 75 | 52 | 49 | 64 |
| St2 | *Stemphylium sp,* | Yozgat | 80 | 55 | 76 | 68 |

## CONCLUSIONS

The sooty mold fungi *Alternaria alternata, Alternaria chlamydosporigena, Alternaria infectoria, Alternaria quercus, Alternaria tenuissima, Alternaria triticina, Cladosporium cladosporioides, Cladosporium herbarum, Cochliobolus sativus, Epicoccum nigrum and Stemphylium sp* can cause molding and spots on leaves and heads in the wheat fields where the harvest delays in Central Anatolia Region. These fungi cause embryo decay in the seed and cause a decline in germination rates. Sooty mold fungi colonize wheat heads when wet, humid weather occurs during the latter stages of grain development and crop maturation, thus harvesting should not be delayed, especially in areas where humidity is high.

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## REFERENCES

Aroca A. & Raposo R. 2007. PCR-based stragety to detect and identify species of *Phaeoacremonium* causing grapevine diseases. *Applied and Environmental Microbiology*, 73, 2911-2918.

Andersen B. & Thrane U. 1996. Diferentiation of *Alternaria infectoria* and *Alternaria alternata* based on morphology, metabolite profiles and cultural characteristics. *Can. J. Microbiol*., 42: 685-689.

Andersen B., Kroger E. & Roberts R.G. 2002. Chemical and morphological segregation of *Alternaria arborescens*, *A. infectoria* and *A. tenuissima* species-group. *Mycological Research*, 106: 170-182.

Anonymous 2010. Compendium of wheat Diseases and Pests. Third Edition, pp. 16-17. Published by APS (*American Phytopathological Society*) St. Paul, Minnesota, USA.

Bhowmik T.P. 1994. *Alternaria* seed infection of wheat. *Plant Dis. Rep*., 53: 77-80, 1969.

Biçici M. & Çinar A. 1988. Çukurova bölgesinde yetiştirilen buğday tanelerinde görülen siyah leke hastalığının etiolojisi ve önemi. *V. Türkiye Fitopatoloji Kongresi*, S. 15, Antalya.

Bockus W.W. 2010. Compendium of wheat diseases and pests (third ed.). St. Paul, Minnesota: APS Press.

Chalkley D. 2012. Systematic Mycology and Microbiology Laboratory, ARS, USDA. Invasive Fungi. Alternaria leaf blight of wheat -*Alternaria triticina*. Retrieved February 14, 2012, from /sbmlweb/fungi/index.cfm.

Chelkowski J. & Visconti A. 1992. Identification were done using '*Alternaria*, Biology, *Plant Diseases and Metabolites*, Elsevier, 573p.

Cobos R. & Martin M.T. 2008. Molecular characterisation of *Phaeomoniella chlamydospora* isolated from grapevines in Castilla y León (Spain). *Phytopathol. Mediterr.*, 47, 20–27.

Dickinson C.H. 1981. Leaf surface micro-organisms as pathogen antagonists and as minor pathogens, In: Strategies for control of cereal diseases. (Eds.): J.F.Jenkyn and R.T. Plumb,

Dash S.K. & Narain A. 1989. Seed transmission of *Alternaria triticina* in wheat in Orissa. *Indian J. Myco.l Plant Pathol*., 19: 24-27.

Dugan, F.M. and S.L. Lupien. 2002. Filamentous fungi quiescent in seeds and culm nodes of weedy and forage grass species endemic to the palouse region of Washington and Idaho. *Mycopathologia* 156: 31-40.

Ellis M.B. 1971. Dematiceous Hyphomycetes. *CMI Publication*, Surrey, Kew, London, UK.

Fakhrunnisa M.H. & Ghaffar A. 2006. Seedborne mycoflora of wheat, sorghum and barley. *Pak. J. Bot*., 38(1): 185-192.

Fakir G.A., Rahman M.H. & Rahman G.M.M. 1989. Survey on the prevalence of black point fungi of wheat in Bangladesh. Bangladesh *J Plant Pathol*. 5: 19-29.Perelló A. & Sisterna M. 2006. Leaf blight of wheat caused by *Alternaria triticina* in Argentina. On Line: *Plant Pathology*, 2005 (NDR 2004-117) http://www.bspp.org.uk/ndr/ july 2005-35.asp. *Plant Pathology* 55 (2), 303-303, 2006. ISSN 1812-538.

Gannibal P., Klemsdal S.S. & Levitin M.M. 2007. AFLP analysis of Russian *Alternaria tenuissima* populations from wheat kernels and other hosts. *Eur. J. Plant Pathl*., 119:175-182.

Hyde M.B. & Galleymore H.B. 1951. The sub-epidermal fungi of cereal grains. II. The nature, identity and origin of the mycelium in wheat. *Ann. Appl. Biol.*, 38: 348-358.

Khanum M., Nigar Y. & Khanzada A.K. 1987. Effect of black point disease on the germination of wheat varieties. *Pakistan J Agric Res* 8: 467-473.

Kosiak B., Torp M., Skjerve E. & Andersen B. 2004. *Alternaria* in Norwegian grains of reduced quality-a matched pair simple study. Int. J. Food Microbiol., 93:51-62.

Lixin W., Xiangji W. & Guangzheng J. 2010. Population and Distribution of Sooty Mould On Leaf Surface Of Wınter Wheat, *Journal of Shandong Agricultural University*.

Magan N. & Lacey J. 1986. The phylloplane microflora of ripening wheat and effect of late fungicide applications. *Annuals of Aplied Biology*, 109: 1, 117–128p.

Mathur S.B. & Cunfer B. 1993. Black Point. In: Seed-borne Diseases and Seed health testing of wheat. Copenhagen, Denmark: *Danish Government Institute of Seed Pathology for Developing Countries,* 13-21.

Özer N. 2005. Determination of the fungi responsible for black point in bread wheat and effects of disease on emergence and seedling vigour. *Trakya Univ. J. Sci*. 6: 35-40.

Perelló A., Moreno V., Sisterna M. & Castro A.M. 2005. Occurrence and characterization on wheat of the *Alternaria infectoria* complex associated with black point and leaf blight symptoms in Argentina. *7th Internacional Wheat Conference*. Nov. 27-Dec 2, 2005. Mar del Plata, Argentina. Organized by SAGPyA and INTA. pp.149.

Perello A., Moreno V. & Sisterna M. 2008. *Alternaria infectoria* species-group associated with black point of wheat in Argentina. *Plant Pathology*, 57: 379.

Perello A. & Larrán S. 2013. Nature and Effect of *Alternaria* Spp. Complex From Wheat Grain On Germination and Disease Transmission. Pak. J. Bot., 45(5): 1817-1824.

Rahman G.M.M &. Islam M.R. 1998. Effect of black point of wheat on some qualitative characters of its grain and seed vigour. Bangladesh J. Agril. Res. 23(2): 283-287,.

Rajput M.A., Pathan M.A., Lodhi A.M., Shah G.S. & Khanzada K.A. 2005. Studies on seed-borne fungi of wheat in Sindh Province and their effect on seed germination. *Pak. J. Bot*., 37(1): 181-185.

Rotem J. 1994. The genus Alternaria: Biology, epidemiology and pathogenicity. St. Paul: *American Phytopathological Society Press*.

White T.J., Bruns T., Lee S. & Taylor J.W. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: PCR Protocols: A Guide to Methods and Applications, eds. Innis, MA, Gelfand DH, Sninsky JJ, White TJ. *Academic Press, Inc*., New York. pp. 315-322.